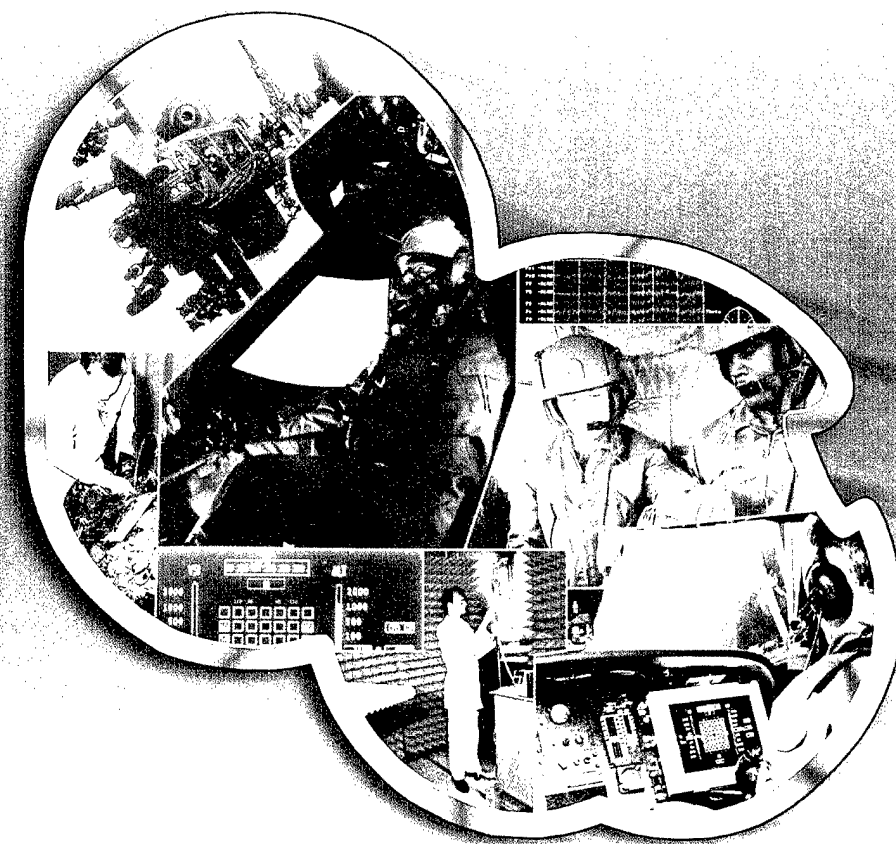


USAARL Report No. 2002-21

A Comparison of AH-64 Pilot Attitudes Toward Traditional and Glass Cockpit Crewstation Designs

by Gregory Francis, Clarence E. Rash, Patricia A. LeDuc, Gina E. Adam,
Stefanie L. Archie, Lisa J. Lewis, Barbara S. Reynolds and Christie L. Suggs



Aircrew Health and Performance Division

August 2002

Approved for public release, distribution unlimited.

20020917 001

U.S. Army
Aeromedical Research
Laboratory

U
S
A
A
R
L

Notice

Qualified requesters

Qualified requesters may obtain copies from the Defense Technical Information Center (DTIC), 8725 John J. Kingman Road, Suite 0944, Fort Belvoir, Virginia 22060-6218. Orders will be expedited if placed through the librarian or other person designated to request documents from DTIC.

Change of address

Organizations receiving reports from the U.S. Army Aeromedical Research Laboratory on automatic mailing lists should confirm correct address when corresponding about Laboratory reports.

Disposition

Destroy this document when it is no longer needed. Do not return it to the originator.

Disclaimer

The views, opinions, and/or findings contained in this report are those of the author(s) and should not be construed as an official Department of the Army position, policy, or decision, unless so designated by other official documentation. Citation of trade names in this report does not constitute an official Department of the Army endorsement or approval of the use of such commercial items.

REPORT DOCUMENTATION PAGE				Form Approved OMB No. 0704-0188			
1a. REPORT SECURITY CLASSIFICATION Unclassified			1b. RESTRICTIVE MARKINGS				
2a. SECURITY CLASSIFICATION			3. DISTRIBUTION / AVAILABILITY OF REPORT Approved for public release, distribution unlimited				
2b. DECLASSIFICATION / DOWNGRADING							
4. PERFORMING ORGANIZATION REPORT NUMBER(S) USAARL Report No. 2002-21			5. MONITORING ORGANIZATION REPORT NUMBER(S)				
6a. NAME OF PERFORMING ORGANIZATION U.S. Army Aeromedical Research Laboratory		6b. OFFICE SYMBOL (If MCMR-UAD	7a. NAME OF MONITORING ORGANIZATION U.S. Army Medical Research and Materiel Command				
6c. ADDRESS (City, State, and ZIP Code) P.O. Box 620577 Fort Rucker, AL 36362-0577			7b. ADDRESS (City, State, and ZIP Code) 504 Scott Street Fort Detrick, MD 21702-5012				
8a. NAME OF FUNDING / SPONSORING ORGANIZATION		8b. OFFICE SYMBOL (If	9. PROCUREMENT INSTRUMENT IDENTIFICATION NUMBER				
8c. ADDRESS (City, State, and ZIP Code)			10. SOURCE OF FUNDING NUMBERS				
			PROGRAM ELEMENT NO. 62787A	PROJECT NO.	TASK NO.	WORK UNIT ACCESSION NO. 178	
11. TITLE (Include Security Classification) (U) A comparison of AH-64 pilot attitudes toward traditional and glass cockpit crewstation designs							
12. PERSONAL AUTHOR(S) G. Francis, C. Rash, P. LeDuc, G. Adam, S. Archie, L. Lewis, B. Reynolds, C. Suggs							
13a. TYPE OF REPORT Final		13b. TIME COVERED FROM TO		14. DATE OF REPORT (Year, Month, 2002 August		15. PAGE COUNT 74	
16. SUPPLEMENTAL NOTATION							
17. COSATI CODES			18. SUBJECT TERMS (Continue on reverse if necessary and identify by block number) cockpit, crewstation design, accident rate, workload, crew coordination, safety				
FIELD	GROUP	SUB-GROUP					
01	02						
24	07						
19. ABSTRACT (Continue on reverse if necessary and identify by block number) Computers and multifunction displays (MFDs) are an integral part of several current Army rotary-wing aircraft. The cockpit design with these types of systems is sometimes called the "glass cockpit." MFDs and computers are also an integral part of the cockpit designs for planned future aircraft. A recent study noted that aircraft with a glass cockpit design have higher accident rates than corresponding aircraft with the traditional cockpit design. This finding suggested that the differences of crewstation design needed to be examined. To identify significant differences, this study assessed pilots' attitudes toward traditional and glass cockpit designs in the AH-64 Apache helicopter. The study identified which aspects of the different cockpit designs were most favorable or troublesome to the pilots, and identified differences in opinions across pilots who flew traditional or glass cockpit designs. The results of the study showed that in general pilots prefer the glass cockpit design of the AH-64D. However, AH-64D pilots did identify issues of higher mental workload and greater difficulty maintaining proficiency after long periods away from the aircraft.							
20. DISTRIBUTION / AVAILABILITY OF ☒ UNCLASSIFIED/UNLIMITED ☐ SAME AS RPT. ☐ DTIC USERS				21. ABSTRACT SECURITY CLASSIFICATION Unclassified			
22a. NAME OF RESPONSIBLE INDIVIDUAL Chief, Science Support Center				22b. TELEPHONE (Include Area (334) 255-6907		22c. OFFICE SYMBOL MCMR-UAX-SS	

Acknowledgements

The authors wish to thank Mr. Art Estrada, CW5 Daniel C. Heath, and CW5 Robert S. Johnson for their assistance.

Special appreciation is, of course, extended to those aviators who took the time to fill out the survey questionnaire.

Table of contents

	<u>Page</u>
Introduction	1
Background	1
Research procedures and methodology	4
Experimental design.....	4
Population	4
Data excluded from the study	4
Instrument	4
Data collection	6
Method of analysis.....	6
Sample demographics	7
Data and results.....	8
Workload.....	8
Safety	11
Crew coordination.....	14
Situational awareness.....	18
Training.....	21
Overall.....	25
Multifunction display details	26
Transition from traditional to glass cockpit model.....	30
Conclusions	33
Recommendations	35
References	37
Appendix A - Questionnaire: A comparison of pilot attitudes toward traditional and glass cockpits in U.S. Army rotary-wing aircraft	39
Appendix B – Written responses to open ended questions.....	55

List of figures

1. Views of the AH-64A traditional cockpit design and the AH-64D glass cockpit design	2
---	---

Table of contents (continued)
List of figures (continued)

	<u>Page</u>
2. Responses for questions 9-14 on workload	9
3. Responses for questions 16-18 on safety	12
4. Responses for questions 20-24 on crew coordination.....	16
5. Responses for questions 26-31 on situational awareness	19
6. Responses for questions 33 and 35 on training.....	23
7. Responses for question 34 regarding the importance of various factors on learning to use the visual displays/instruments	23
8. Responses for question 37 on overall inclusion of MFDs	25
9. Responses to question 39 about the physical features of MFDs in the AH-64D aircraft	27
10. Responses to question 40 about the information content provided by the MFD.....	28
11. Responses to question 41 about working with the MFD	29
12. Responses to question 43 about the transition from the A-model to the D-model.....	31
13. Responses from question 44 comparing the aircraft with different crewstation designs	33

Introduction

Computers and multifunction displays (MFDs) are an integral part of several current Army rotary-wing aircraft. The cockpit design with these types of systems is sometimes called the "glass cockpit." MFDs and computers are also an integral part of the cockpit designs for planned future aircraft. A recent study by Rash et al. (2001) noted that aircraft with a glass cockpit design have higher accident rates than corresponding aircraft with the traditional cockpit design. This finding suggested that the differences in crewstation designs needed to be examined. To identify significant differences, this study assessed pilots' attitudes toward traditional and glass cockpit designs in the AH-64 Apache helicopter. The study identified which aspects of the different cockpit designs were most favorable or troublesome to the pilots, and identified differences in opinions across pilots who flew traditional or glass cockpit designs. The results of the study identify which areas of cockpit design require further investigation.

Background

The crewstation instrument panel of aviation cockpits is undergoing radical change. Computers and MFDs now replace many traditional displays of gauges and dials (compare the cockpit designs in Figure 1). The new design is sometimes referred to as a "glass cockpit" to indicate the presence of computer screens in the MFDs on the crewstation instrument panel. The development of glass cockpit designs was seen as necessary to reduce the clutter of traditional cockpit designs and to provide the aircraft with enhanced capabilities that would not fit into the traditional cockpit design (e.g., Silverio and Drennen, 1985). Glass cockpit designs are part of many new aircraft, both in commercial and military aviation. The U. S. Army has integrated the glass cockpit scheme into four rotary-wing aircraft types: the AH-64 Apache, the CH/MH-47 Chinook, the OH-58 Kiowa, and the UH/MH-60 Black Hawk. The glass cockpit models of these aircraft are designated as the AH-64D, MH-47E, OH-58D, and MH-60K, respectively. In addition, the MH-47D and MH-60L have crewstation configurations that are referred to in the industry as hybrids because they mix MFDs and dedicated instruments. The distinction between a glass cockpit and a hybrid configuration is not simple because all glass cockpits models also include some dedicated instruments.

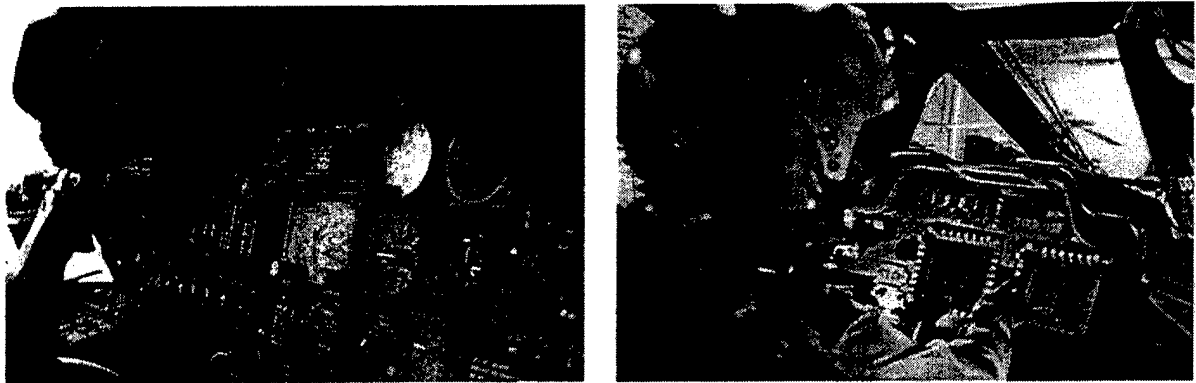


figure 1. Views of the AH-64A traditional cockpit design (left) and the AH-64D glass cockpit design (right).

Flying an aircraft is a highly specialized task that requires crewmembers to learn a large set of skills to operate the visual displays and instruments. Pilots fly differently with glass cockpit and traditional designs. For example, Degani, Chappell and Hayes (1991) studied incident reports where crewmembers of commercial fixed wing aircraft detected a potentially dangerous situation and implemented appropriate measures to avoid an accident. The study demonstrated that the flight crew in a glass cockpit design was more likely to detect a potential problem than the flight crew in a traditional design (most of the other detections of incidents were made by air traffic controllers). On the other hand, several studies have noted problems and concerns about glass cockpit designs in commercial aviation (Funk and Lyall, 1997; Wiener, 1989; Wiener and Curry, 1980; Sarter and Woods, 1995). Common concerns are that computer automation introduces pilot boredom and reduces situational awareness. Despite the concerns, pilots generally approve of the introduction of glass cockpit designs, and there is significant evidence that commercial aircraft with a glass cockpit design have fewer accidents that lead to hull loss (Funk and Lyall, 1997).

The effect of glass cockpit designs in military rotary-wing aviation has not been investigated as fully as in the commercial sector. Glass cockpit designs in rotary-wing military aircraft do not introduce nearly the level of automation that is used by fixed wing commercial aircraft, so many of the concerns about pilot boredom in commercial aircraft may not transfer to the military rotary-wing pilots. Given the dramatic differences between the pilot's roles in commercial and military situations, it may be inappropriate, without some outside justification, to apply conclusions from one sector to the other.

The different purpose and function of glass cockpits in fixed wing commercial and rotary-wing military aircraft seems to be represented in some data sets. Although there is convincing evidence that glass cockpit designs lead to fewer accidents in fixed wing commercial aircraft (Funk and Lyall, 1997), the same does not seem to be true for military rotary-wing aircraft. Rash et al. (2001) compared accident rates for Army rotary-wing aircraft that have both traditional and glass cockpit models. The accident rate for the OH-58 was much higher for the glass cockpit version of the aircraft than for the traditional version (statistical analyses confirmed that the difference was significant). Similar results were found for the AH-64, UH-60, and CH-47,

although the flight-hour data for the glass cockpit designs were too small to reach statistical significance. Contrary to the commercial sector, in these military aircraft, the introduction of a glass cockpit design did not improve overall safety.

There are also discrepancies between the expected characteristics of the glass cockpit design and some pilots' impressions. A formal investigation of the preliminary airworthiness of the OH-58D (Bender et al., 1984) predicted that workload levels would be manageable, except for a few specific situations. Low workload is also the first listed feature of the OH-58D in a product brochure produced by its manufacturer (Bell Helicopter Textron Inc., 1988). In contrast, two Army OH-58D pilots (Ramsey and Altman, 1998) speculated that the glass cockpit design in the OH-58D results in task overload and a loss of situational awareness.

In a similar vein, a formal workload study by Hamilton, Bierbaum and McAnulty (1994), predicted that workload would generally be reduced as pilots went from the AH-64A to the AH-64D. However, unstructured interviews conducted with AH-64D pilots suggest that there is perceived to be higher overall workload in the glass cockpit aircraft than in the traditional cockpit design model (the AH-64A).

The current measures of pilot perceptions have been anecdotal and thereby had limited utility. A formal investigation of pilots' attitudes toward the cockpit design of their aircraft was necessary. Practically, it is unfeasible to objectively measure all aspects of crew interaction with the visual displays and instruments. It is unfeasible because there are too many factors involved in flying a helicopter. To try to gain a handle on the areas that may be most important with regard to interacting with the visual displays/instruments, we elected to query active pilots. These pilots have first-hand knowledge of what type of effort is required to interact with the different cockpit designs.

The current fleet of Army rotary-wing aircraft provided an opportunity to compare cockpit designs. The aircraft with glass cockpit designs are similar to those with the traditional design. Although there are differences in handling and capabilities for some aircraft types, comparisons between traditional and glass cockpit models include a fairly good experimental control. This type of balance will not exist in the near future, as new aircraft will likely be built only with a glass cockpit design (e.g., the RAH-66 Comanche).

This paper reports partial findings of a study that investigated U.S. Army aviator attitudes regarding workload, safety, crew coordination, situational awareness, and training as a function of crewstation design. This paper compares the traditional and glass cockpit models of the AH-64 series aircraft. A companion paper reports the attitudes of OH-58 pilots toward their aircraft. Aviators from other U.S. Army aircraft series with both traditional and glass cockpit models (i.e., CH-47 and UH-60) were not included because there were either very few pilots rated for the glass cockpit models for these two aircraft series or it was deemed to be too difficult to reach the populations of pilots. To keep the size of the discussion manageable, this paper only considers the attitudes of AH-64 pilots toward their aircraft.

Research procedures and methodology

Experimental design

The design for this study consisted of a combined quantitative and subjective (respondent comments) approach. The unit of analysis was Army aviators. A survey questionnaire was used as the instrument for data collection. Participation was limited to AH-64 and OH-58 aviators. Questionnaire items were developed primarily to investigate the attitudes of pilots toward the visual displays and instruments in their aircraft. The main comparison was between pilots who fly traditional versus glass cockpit models.

Population

The populations of interest were AH-64 (A and D models) rated aviators and aviators in the Aircraft Qualification Course (AQC) for these aircraft. Both active duty and National Guard aviators were included. These populations are located at diverse Army posts around the world. High concentrations of these populations exist at Fort Rucker, Alabama (U.S. Army Aviation Center), Fort Campbell, Kentucky, and Fort Hood, Texas.

The current estimated population sizes for AH-64 aviators indicate that there are 874 AH-64A pilots as well as 265 AH-64D pilots in active duty and National Guard units.

Data excluded from the study

Two submitted questionnaires were removed from the study. Their removal was based primarily on level of completeness. An acceptable questionnaire was defined as one in which the respondent provided responses to at least 90% of those questions which were applicable to the respondent's indicated aircraft experience. Specific responses to questions were treated as missing data if these responses fell into one of the following categories: Multiple answer response, no response, illegible response, or irrelevant response. Of the removed questionnaires, one did not report the primary aircraft and the other only answered questions on the first page.

Instrument

The instrument used was a paper questionnaire developed by researchers at the U.S. Army Aeromedical Research Laboratory (USAARL), Fort Rucker, AL. Individual questions were evaluated for validity by USAARL research aviators. A copy of the questionnaire is provided in Appendix A.

The questionnaire consisted of a common set of 8 demographic questions and 31 research questions about the visual displays/instruments in their aircraft. The research questions were organized into six main areas: Workload, safety, crew coordination, situational awareness, training, and overall opinion. Each area provided one open-ended question where respondents were asked to suggest any changes to the visual displays/instruments.

The questions on workload were designed to cover topics that are generally recognized as contributing to workload (e.g., the National Aeronautics and Space Administration Task Load Index (NASA TLX), Hart and Staveland, 1988). These topics included mental activity, physical activity, performance time, and frustration. Additional questions tried to assess whether the aviator felt the workload levels were manageable and comfortable. The questions did *not* measure workload directly, but instead asked the aviator to provide an opinion about various aspects of interacting with the visual displays/instruments. The responses can be taken as the aviator's attitude about factors that are related to workload.

The questions on safety tried to gauge the aviator's attitude about the aircraft's accident rate and whether the visual displays and instruments have much impact on the aircraft's safety.

The questions on crew coordination were based on the Aircrew Coordination Exportable Training Package Student Guide (Department of Defense, 1992), a training document on crew coordination. This guide is part of a course on crew coordination taught to all aviators.

The questions on situational awareness were designed to measure the aviators' attitudes about whether the visual displays and instruments help maintain awareness of the aircraft status and flight environment. Some of the questions were loosely based on the SART technique for measuring situational awareness (Taylor, 1990). However, the questions did *not* try to directly measure situational awareness. The questionnaire was only trying to measure aviators' attitudes about how they think the visual displays and instruments influence situational awareness.

The questions on training focused on three issues. The first issue was how difficult it was to learn to use the visual displays and instruments. The second issue was to rank order the various factors during training and flying of the aircraft according to how much they contributed to learning to use the visual displays/instruments. In conversations, aviators have indicated that learning to use the glass cockpit aircraft required additional experience after formal training. The third issue also was identified by conversations with aviators. Several aviators flying with glass cockpit crewstations stated that after a period of time away from the aircraft, there was a loss of proficiency flying the aircraft, and relearning was required to return to an appropriate level. We asked aviators how much of the loss was related to interaction with the crewstation instruments.

The "overall" questions allowed respondents to indicate their general view of the use of MFDs in rotary-wing aircraft.

In addition to the questions in the six main research areas, two additional areas were to be answered by a subset of the respondents. All aviators who were responding about a glass cockpit model (AH-64D) were asked to answer questions about details of the MFD. The first question focused on the physical characteristics of the MFD and visibility of the screen. The second question focused on the information content of the MFD. The final question focused on the aviator's awareness of what the MFD was doing and how to get information from the MFD.

All aviators who were responding about a glass cockpit model and had previously flown a traditional cockpit model of the same aircraft (AH-64A) were asked questions about the transition from the traditional to the glass cockpit models. They also were asked to compare the models across a number of general issues.

Data collection

Questionnaires were distributed via two mechanisms. The most extensive distribution was accomplished via mailing questionnaires to aviation unit safety officers at aviation posts both within and outside of the continental United States. Safety officers were requested to disseminate the questionnaires at monthly safety briefings. Where possible, the unit safety officers were sent email reminders one month after the initial questionnaire mailing.

The second distribution mechanism was via the annual U.S. Army Forces Command (FORSCOM) Aviation Safety Officers' Conference held in Atlanta, GA, in March 2002. Attendees were briefed on the scope and purpose of this study and were requested to carry additional questionnaires back to their respective units.

Since the data gathered are the result of a voluntary survey rather than a random sample, readers are cautioned about inferring specific findings to the general population. Nevertheless, the demographic data described below seem representative of the population and we have no knowledge of systemic deviations of our sample from the population.

Method of analysis

The primary purpose of this study was to look for systematic differences in responses from the aviators who fly the traditional and the glass cockpit models. Although no *a priori* hypotheses were formulated, our discussions with aviators suggested that aviators of glass cockpit designs may report higher workload, poorer situational awareness of the flight environment, and more difficult training. Except for demographic data, questionnaire responses were of two types. A majority of the questions were presented using Likert scales that included various forms of replies that measured different levels of satisfaction, agreement, or rank. The remaining questions required hand-written comments of a qualitative nature.

The data for each question were described by reporting the percentages of times pilots gave each response answer. This information is provided in a bar graph that contrasts the data from the AH-64A and AH-64D pilots. This information describes the attitudes of pilots about the topic of the question. In addition, a Mann-Whitney U-test was used to compare responses from the AH-64A pilots to responses from the AH-64D pilots. The Mann-Whitney test determines whether there is evidence that the two sets of responses come from different populations. The Mann-Whitney test is a non-parametric statistical procedure for judging the statistical significance of differences in the pattern of responses. When there was a statistically significant difference in attitude across the aircraft, the nature of the difference was discussed. Tables with the frequency of responses for each question are shown in Appendix A.

Sample demographics

The table presents the central tendencies of the sampled data demographics. Note that the number of responses to some questions does not match the total number of respondents because some respondents did not answer some questions.

One noteworthy characteristic of the demographic data was that the AH-64A pilots have, on average, as many flight hours in the AH-64D aircraft as the AH-64D pilots have. This seemingly odd situation is due to the fact that many of the AH-64D pilots are currently in an AQC learning how to fly the AH-64D aircraft. Thus, many of the AH-64D pilots do not yet have many flight hours. Additional details of the demographic data are available in Appendix A.

Table.

Summary of demographic information broken down by AH-64A and AH-64D pilots.

	AH-64A	AH-64D
Number of respondents	134	164
Primary position:		
Pilot	31	18
co-pilot	39	36
AQC	1	61
Mean age	33.87	31.05
Median year graduated IERW	1995	1997
Mean total rotary-wing flight hours	1389	1000
Mean flight hours for:		
AH-64A	921	687
AH-64D	66	74
OH-58A/C	267	166
OH-58D	114	158
Other	314	328
Number respondents who are:		
Instructor pilot	56	17
Line pilot	67	44
Test/maintenance pilot	3	12
AQC	3	78
Other	5	9
Number respondents from:		
Fort Bragg	30	0
Fort Campbell	28	5
Fort Hood	2	52
Fort Rucker	41	68
Other	33	39

Data and results

Data were collected for five research areas (i.e., workload, safety, crew coordination, situational awareness, and training), overall opinion of crewstation design approaches, acceptability and use of MFDs, and comparison of traditional and glass cockpit crewstation designs (when appropriate).

Representative responses from the open-ended questions are provided in the discussion. All of the responses to open-ended questions are presented in Appendix B. Occasionally, responses were edited slightly to improve fragmentary responses, verbal lacunae, or misspellings. Places where this occurred were indicated with square brackets [].

Workload

The workload section of the questionnaire consisted of 6 objective questions (#9-14), where each respondent was asked to report on some aspect of crewstation workload using numbers between 1 and 5. One additional question was subjective and open-ended, requesting aviator suggestions on changes to “visual displays/instruments” which might decrease workload. The following sections summarize the data.

Analysis

Figure 2 plots the distribution of responses for each workload question. Each bar plot contains data from both aircraft types for a specific question. The responses of four of the six questions differed significantly between the AH-64A and the AH-64D pilots.

Question 9 asked pilots to characterize the amount of mental activity involved in working with the visual displays/instruments on a scale between “Very little” (coded as 1) and “Very much” (coded as 5). The opinions of pilots in the AH-64A versus the AH-64D aircraft were dissimilar ($U=8580.5$, $p=0.001$). As Figure 2 indicates, the difference seems to be that the AH-64D pilots tended to have more responses toward the “Very much” end of the scale and fewer middle responses than the AH-64A pilots. Quantitatively, 57% of the AH-64D pilots responded with the choices on the “Very much” side of the scale, while only 34% of the AH-64A pilots selected those choices.

Question 10 asked pilots to rate the amount of physical activity involved in working with the visual displays/instruments on a scale between “Very little” (coded as 1) or “Very much” (coded as 5). Any differences in ratings across aircraft were not statistically significant ($U=9957.5$, $p=0.150$). As Figure 2 indicates, the responses tend to be symmetric around the middle of the scale for both aircraft types.

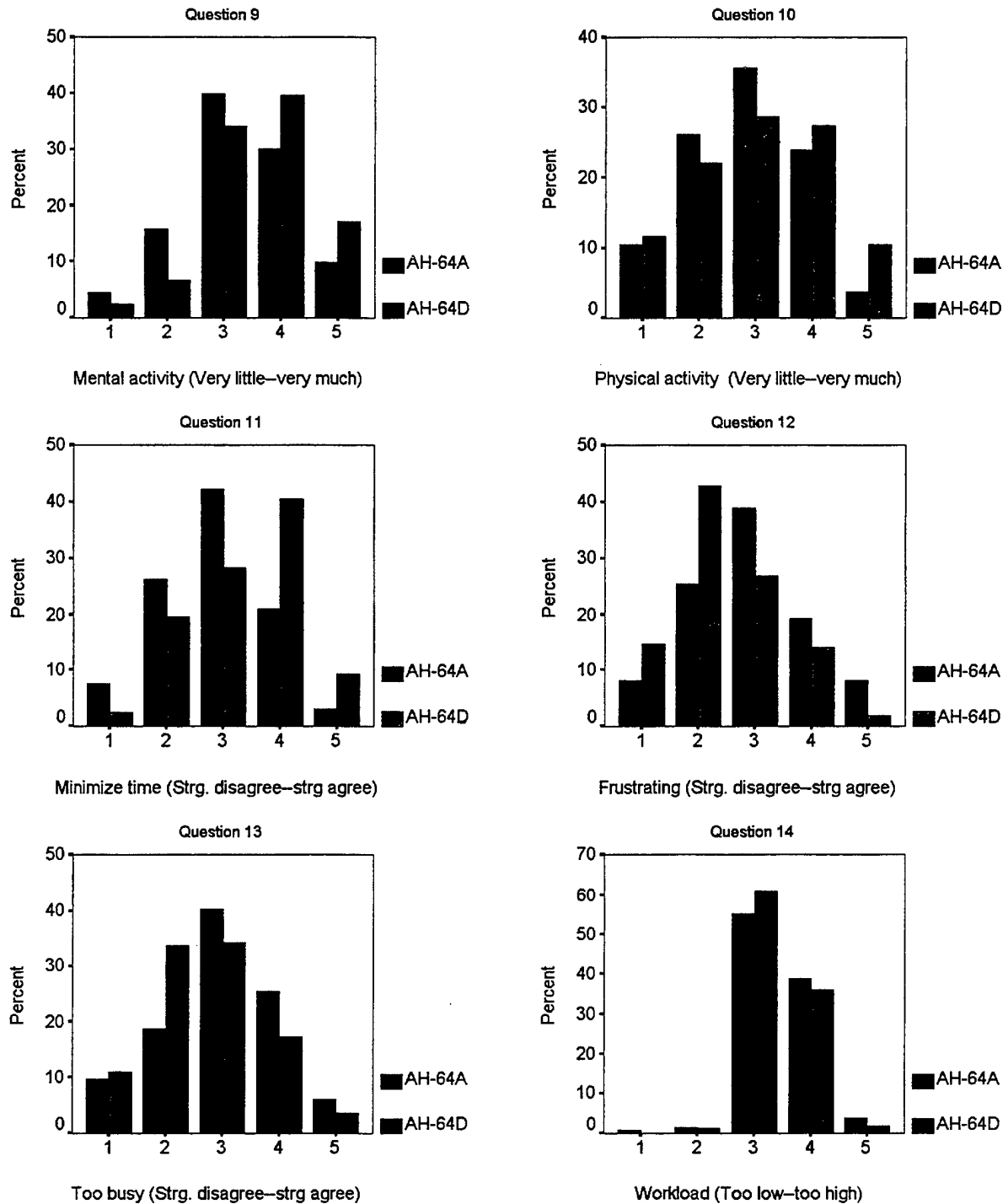


Figure 2. Responses for questions 9-14 on workload. Responses for the AH-64A pilots are in red (dark gray) and responses for the AH-64D pilots are in green (light gray).

Question 11 asked pilots to indicate whether they agreed that the visual displays/instruments minimized the time required to perform tasks. The left side of the scale was marked as “Strongly

disagree” (coded as 1) and the right side of the scale was coded as “Strongly agree” (coded as 5). The middle of the scale was coded as “Neutral.” The opinions of pilots in different aircraft were different ($U=7866.0$, $p=0.000$). As Figure 2 indicates, the difference seems to be that the AH-64A pilots had most responses in the middle of the scale with a fairly symmetric pattern for the extremes, while the AH-64D pilots had responses skewed to the “Strongly agree” side of the scale. Among the AH-64D pilots, 49% chose responses from the agree side of the scale, while only 24% of the AH-64A pilots chose such responses.

Question 12 asked pilots to indicate whether they agreed that the design of the visual displays/instruments was frustrating. The opinions of pilots in the AH-64A versus the AH-64D aircraft were dissimilar ($U=8131.5$, $p=0.000$). As Figure 2 indicates, the difference seems to be that the AH-64A pilots had most responses in the middle of the scale with a fairly symmetric pattern for the extremes, while the AH-64D pilots had responses skewed to the “Strongly disagree” side of the scale. Among the AH-64D pilots, 58% chose responses from the disagree side of the scale, while only 33% of the AH-64A pilots chose such responses.

Question 13 asked pilots to indicate whether they agreed that the design of the visual displays/instruments kept them busier than they needed to be. The opinions of pilots in the AH-64A versus the AH-64D aircraft were dissimilar ($U=8991.5$, $p=0.006$). As Figure 2 indicates, the difference seems to be that the AH-64A pilots had most responses in the middle of the scale with a fairly symmetric pattern for the extremes, while the AH-64D pilots had responses skewed to the “Strongly disagree” side of the scale. Among the AH-64D pilots, 45% of the responses were on the disagree side of the scale, while only 29% of the AH-64A pilot chose such responses.

Question 14 asked pilots to rate whether workload related to the visual displays/instruments is “Too low” (coded as 1), “Too high” (coded as 5), or “About right” (middle). Any differences in ratings across aircraft were not statistically significant ($U=10475.5$, $p=0.424$). As Figure 2 indicates, for both aircraft types, the responses tend to be clustered around the “About right” response or one step toward the “Too high” response. Pilots from both aircraft are much more likely to rate the workload related to the visual displays/instruments as high rather than low.

Respondent comments

As this was the first open-ended question, many pilots used it to discuss a variety of topics and suggestions on the visual displays/instruments.

Many AH-64A pilots addressed the inadequacy of the FLIR (Forward Looking Infrared) system and commented that the ORT (Optical Relay Tube) blocked their view of instruments. Additionally, many AH-64A pilots indicated that all aircraft should be upgraded to the D-model visual displays/instrument systems. Representative comments from the AH-64A pilots are:

- Remove the ORT and replace it with CRT [cathode ray tube]. Keep the front and back seat instrumentation as similar as possible. Symbolic and actual indications should match i.e., TQ [torque].

- The ORT makes workload extremely hard. Removing the ORT and designing a new hands on terminal for gunnery purposes will be better used.
- Update the FLIR to current technology.
- Move to AH-64D design in all aircraft.

Other pilots offered some specific recommendations, and these are detailed in Appendix B.

The AH-64D pilots also commented on the need for an improvement to the FLIR system and that the ORT should be removed and replaced with another MFD. Representative comments from the AH-64D pilots are:

- New FLIR, binocular sights, NVG [night vision goggle] usage should all be considered.
- Get rid of ORT and put in an MPD [multi purpose display].
- Need a third MPD in front seat of AH-64D. The ORT currently in use is too small of a screen to be easily viewed when on a mission. Also, ORT handles are entirely too "busy". Some of the function buttons should be moved to the third screen bezel.
- With only two displays, I tend to feel restricted as to what information is immediately available while in flight, as compared to what is available.

Several comments also indicated satisfaction with the visual displays/instruments, and other comments addressed fairly specific details of the visual displays/instruments. Many pilots also made comments about the learning process (several pilots commented that as they were in the AQC, they thought their opinions would change later). All of the comments are provided in Appendix B.

Conclusions

The statistical analysis indicated differences in opinion between the AH-64A (traditional cockpit) and AH-64D (glass cockpit) pilots. The traditional cockpit seemed to be easier to use, as the overall mental activity was judged to be lower by the AH-64A pilots. However, the AH-64D pilots gave higher ratings for the minimization of time required to perform tasks, and they gave lower ratings for the visual displays/instruments design being frustrating and for the visual displays/instruments causing unnecessary busyness. Thus, a summary of pilot attitudes on workload is that although the glass cockpit appears to require the AH-64D pilots to do more mental work, it does so in a way that is cleaner and better than the traditional cockpit design. This is consistent with personal interviews with AH-64 pilots who have transitioned from the A to D models.

Safety

The safety section of the questionnaire consisted of 3 objective questions (#16-18), where each respondent was asked to rate some measure of safety on a scale between 1 and 5. One additional question was subjective and open-ended, requesting aviator suggestions on changes to the visual displays/instruments that might improve safety. The following sections summarize the data responses.

Analysis

Figure 3 plots the distributions of responses for each question dealing with safety. Each bar plot contains data from both aircraft types for a specific question. The responses of one of the three questions differed significantly between the AH-64A and the AH-64D pilots.

Question 16 asked pilots to rate between “Very little” and “Very much,” how much they thought the visual displays/instruments contributed to accidents in their aircraft. Any differences in ratings across aircraft were not statistically significant ($U=10347.5$, $p=0.793$). As Figure 3 indicates, while most responses were near the center of the scale, for both aircraft types there was a bias for responses among the “Very little” end of the scale.

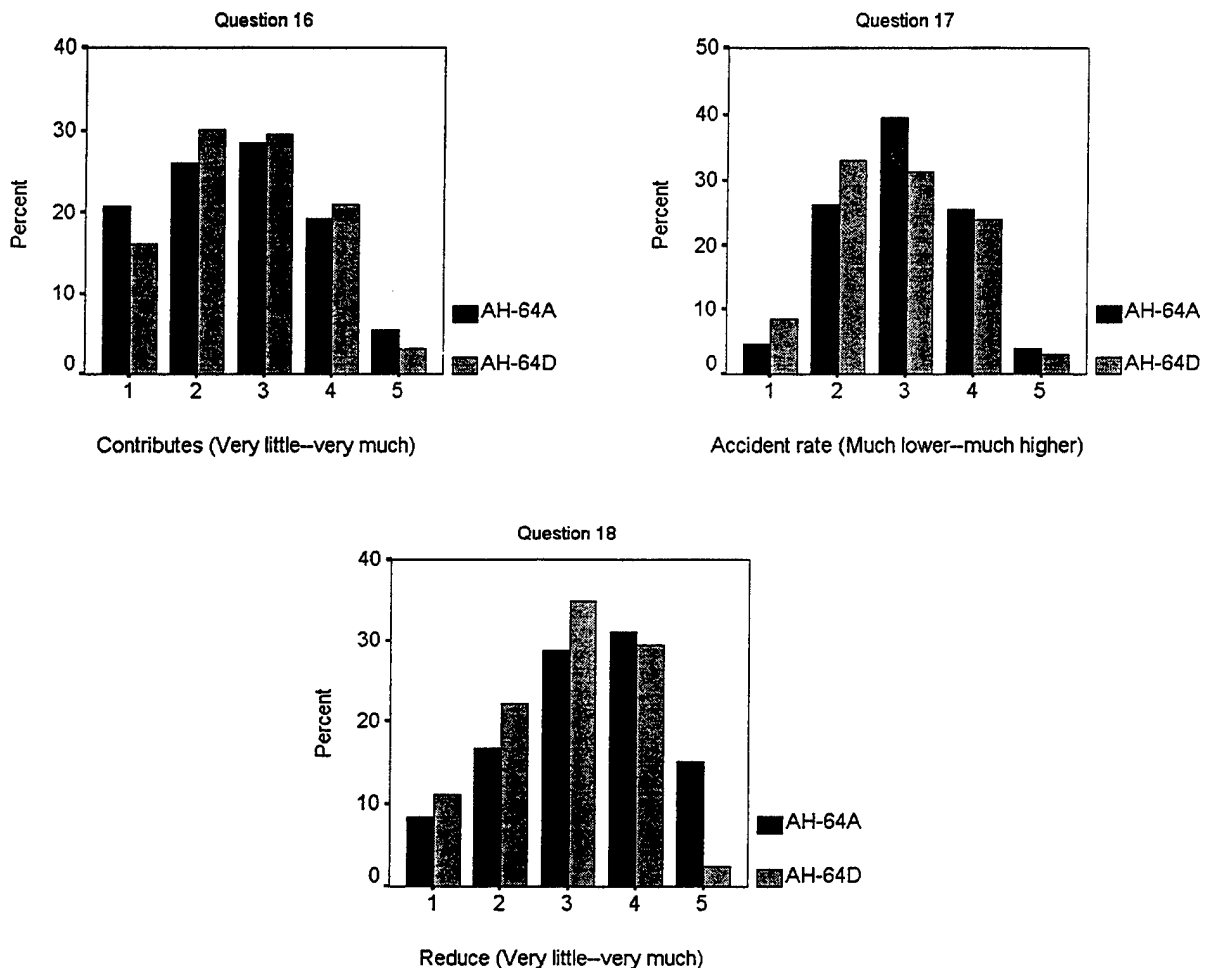


Figure 3. Responses for questions 16-18 on safety. Responses for the AH-64A pilots are in red (dark gray) and responses for the AH-64D pilots are in green (light gray).

Question 17 asked pilots to judge whether they thought the accident rate for their aircraft was higher or lower than the fleet average accident rate (9.46). The middle position of the scale was marked as "Same." Any differences in ratings across aircraft were not statistically significant ($U=9449.5$, $p=0.121$). As Figure 3 indicates, most responses were near the center of the scale and fell symmetrically for the more extreme opinions. It is worth noting that the pilots' responses do not reflect the actual data. The accident rate for the AH-64A and AH-64D models over the years asked in the question was actually much higher than the fleet average. For the AH-64A, the accident rate was 17.16 accidents per 100,000 flight hours, while for the AH-64D, the accident rate was 22.44 (Rash et al., 2001).

Question 18 asked pilots to rate between "Very little" and "Very much", how much they thought the visual displays/instruments could be improved so as to reduce accidents in their aircraft. The opinions of pilots in the AH-64A versus the AH-64D aircraft were dissimilar ($U=8735.0$, $p=0.004$). As Figure 3 indicates, the primary difference seems to be that the AH-64A pilots had more "Very much" responses than the AH-64D pilots. Among the AH-64D pilots, only 31% of the responses were on the "Very much" side of the scale, while 46% of the AH-64A pilots chose such responses.

Respondent comments

Many of the comments on the open-ended safety question were similar to the comments provided after the workload question.

AH-64A pilots again mentioned the inadequacy of the FLIR system and complained that the ORT blocked their view of instruments. Additionally, many pilots commented that the front and back seats should have compatible systems. Representative comments of the AH-64A pilots were:

- Full view of symbology and FLIR picture.
- Remove the ORT and replace it with CRT. Keep the front and back seat instrumentation as similar as possible. Symbolic and actual indications should match i.e., TQ. Improve the caution-warning panel to be the same as the back seat.
- The missile system is too complicated, too many switches, the ORT head's out display is too small and Gen 1 FLIR is poor and dangerous.
- Change the lighting in AH-64A to blue green. Get rid of ORT and make hand grips smaller.

Other pilots offered some specific recommendations, and these are detailed in Appendix B. In many cases, pilots wrote "See previous written answer," or some comparable phrase. In such a case, we copied what they had previously written as an answer for this question. This duplication was done for every question.

The AH-64D pilots also commented on the need for an improvement to the FLIR system and that the ORT should be removed and replaced with another MFD. In addition, several pilots

Other pilots offered some specific recommendations, and these are detailed in Appendix B. In many cases, pilots wrote "See previous written answer," or some comparable phrase. In such a case, we copied what they had previously written as an answer for this question. This duplication was done for every question.

The AH-64D pilots also commented on the need for an improvement to the FLIR system and that the ORT should be removed and replaced with another MFD. In addition, several pilots commented on problems with viewing the MFDs and on a need for more permanent representations of some types of data. Representative comments of the AH-64D pilots were:

- It would be nice to have engine page instruments displayed at all time.
- Eliminate the ORT in AH-64D CPG [copilot/gunner] station and replace with MPD. This would allow CPG to better divide focus inside and outside.
- MPD's and dashboard in backseat are about 1-2" too low. As a longer legged pilot, I cannot use park brake in back seat and can't see all of MPDs in front seat.
- Use analog instruments - a circled compass rose is generally missed. I used to just see 45 and 90 degree tick marks on the HSI [horizontal stabilizer indicator] . Now with only a hdg [heading] tape, I have to do the math in my head for traffic pattern work.

Several pilots also commented that the MFDs tended to keep them "inside" the aircraft and that some of the paging procedures could use improvement. All of the comments are provided in Appendix B.

Conclusions

The analysis suggests that pilots of both aircraft do not consider the current visual displays/instruments in their aircraft to be strongly related to accidents. This was not a particularly surprising result because accidents are rare and are often related to specific circumstances where the role of the visual displays/instruments (if they played any role) would be secondary or tertiary in nature. Nevertheless, it was interesting to note that pilots from both aircraft seemed to believe their aircraft was safer than the actual accident rate data suggests. Moreover, there was a difference of opinion regarding whether improvements could be made. The AH-64A pilots indicate that improvements to the visual displays/instruments could reduce the accident rate.

Crew coordination

The crew coordination section of the questionnaire consisted of 5 objective questions (#20-24), where each respondent was asked to indicate whether they "Strongly disagree" (coded as 1) or "Strongly agree" (coded as 5) with the question statement. The middle position was marked as "Neutral." One additional question was subjective and open-ended, requesting aviator suggestions on changes to the visual displays/instruments that might improve crew coordination. The following sections summarize the data responses.

Analysis

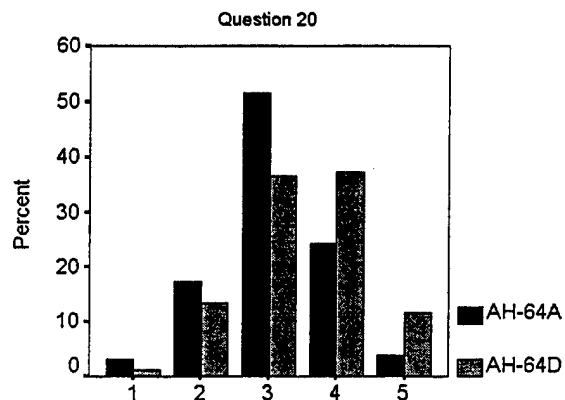
Figure 4 plots the distributions of responses for each question dealing with crew coordination. Each bar plot contains data from both aircraft types for a specific question. The responses of all five questions differed significantly between the AH-64A and the AH-64D pilots.

Question 20 asked pilots if they agreed that the visual displays/instruments contributed to positive crew relationships. The opinions of pilots in the AH-64A versus the AH-64D aircraft were dissimilar ($U=8411.5$, $p=0.000$). As Figure 4 indicates, while both pilot groups tended to agree with this statement, the AH-64D pilots had a higher percentage of responses on the "agree" side of the scale. Among the AH-64D pilots, 49% of the responses were on the agree side of the scale, while only 28% of the AH-64A pilot chose such responses.

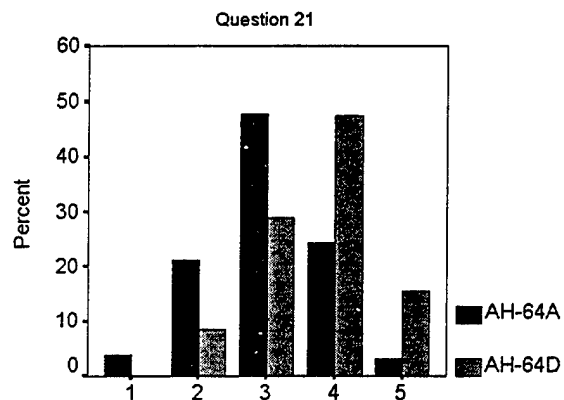
Question 21 asked pilots if they agreed that the visual displays/instruments promoted redistribution of crewmember responsibilities. The opinions of pilots in the AH-64A versus the AH-64D aircraft were dissimilar ($U=6344.5$, $p=0.000$). As Figure 4 indicates, the AH-64A pilots were largely in the middle of the scale, while the AH-64D pilots were largely on the "agree" side of the scale. Among the AH-64D pilots, 62% of the responses were on the agree side of the scale, while only 27% of the AH-64A pilot chose such responses.

Question 22 asked pilots if they agreed that the visual displays/instruments supported free flow of information among crewmembers. The opinions of pilots in the AH-64A versus the AH-64D aircraft were dissimilar ($U=6104.0$, $p=0.000$). As Figure 4 indicates, the AH-64A pilots were largely in the middle of the scale, while the AH-64D pilots were largely on the "agree" side of the scale. Among the AH-64D pilots, 67% of the responses were on the agree side of the scale, while only 30% of the AH-64A pilots chose such responses.

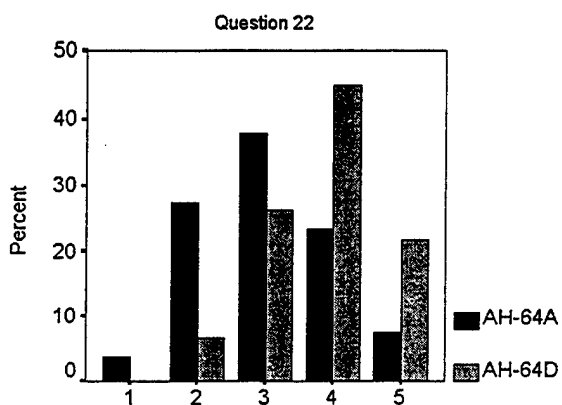
Question 23 asked pilots if they agreed that the visual displays/instruments promoted cross-monitoring of actions and decisions. The opinions of pilots in the AH-64A versus the AH-64D aircraft were dissimilar ($U=7843.0$, $p=0.000$). As Figure 4 indicates, the AH-64A pilots were largely in the middle of the scale, while the AH-64D pilots were largely on the "agree" side of the scale. Among the AH-64D pilots, 63% of the responses were on the agree side of the scale, while only 30% of the AH-64A pilots chose such responses.



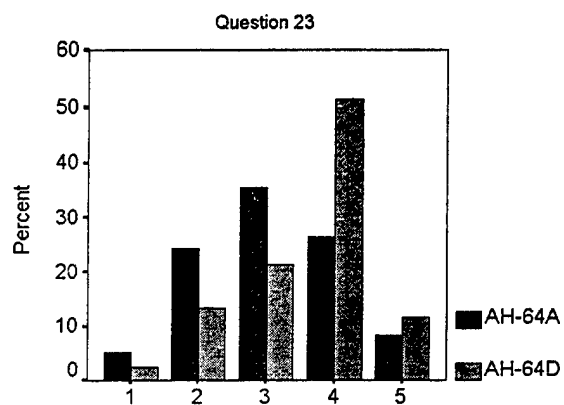
Relationships (Strg. disagree-strg. agree)



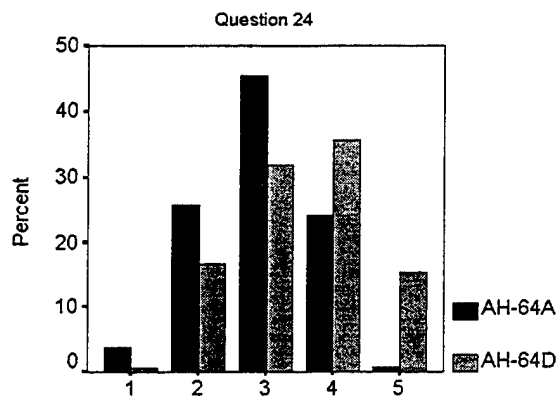
Redistribution (Strg. disagree-strg. agree)



Info flow (Strg. disagree-strg. agree)



Monitoring (Strg. disagree-strg. agree)



Coordination (Strg. disagree-strg. agree)

Figure 4. Responses for questions 20-24 on crew coordination. Responses for the AH-64A pilots are in red (dark gray) and responses for the AH-64D pilots are in green (light gray).

Question 24 asked pilots if they agreed that the visual displays/instruments promoted good crew coordination. The opinions of pilots in different aircraft were different ($U=7374.0$, $p=0.000$). As Figure 4 indicates, the AH-64A pilots were largely in the middle of the scale, while the AH-64D pilots were largely on the “agree” side of the scale. Among the AH-64D pilots, 51% of the responses were on the agree side of the scale, while only 25% of the AH-64A pilots chose such responses.

Respondent comments

AH-64A pilots commented that common instruments between the front and back seats and the ability to assess what the other crew member was doing would help crew coordination. Additionally, several pilots commented that the front seat needed drift information. Representative comments of the AH-64A pilots were:

- Front seat needs drift and climb rate info during target engagement to predict impact point of weapons.
- Need to be like cockpits with the ability to confirm opposite seat inputs.
- Many things in the A model Apache are cockpit specific and are not duplicated in each cockpit. This prevents sharing workload to a point.
- Lack of crew station commonality instrumentation contributes to the necessity of excessive verbal communication in a tandem seat aircraft.

Other pilots offered some specific recommendations, and these are detailed in Appendix B.

Many AH-64D pilots reported that an ability see what the other crew member was looking at on the MFD would help improve crew coordination. Another common comment was that the impetus for good crew coordination was on the crewmembers and not related to the instruments. On the other hand, several pilots commented that the visual displays/instruments in the AH-64D made crew coordination more important than ever because different crew members could do very different things at the same time. Representative comments of the AH-64D pilots were:

- Small window stating what MPDs pages are up in the other cockpit.
- Crew coordination is made more difficult because the front seat pilot must devote much time to setting up the battlefield properly, the pilot in the back seat does not see changes as they are happening.
- The designs do not promote crew coordination. The crew members must initiate crew coordination.
- Change indication of the page displayed and functions selected by one crew member when the same page is viewed by opposite crewmember. This would help avoid continually selecting the same function by both crew members at the same time.

All of the comments are provided in Appendix B.

Conclusions

The analysis suggests that pilots of the AH-64D model believed the visual displays/instruments contributes positively to crew coordination, while the AH-64A pilots felt more neutral about the visual displays/instruments' contributions. It may also be significant that many of the written responses from the AH-64D pilots indicated concerns about crew coordination with the glass cockpit design. Several pilots commented that since each crew member could do so many different tasks, it was easy to lose track of what the other person was doing. This combination of findings suggests that while the AH-64D has many properties that promote good crew coordination, there may be room for additional improvement.

Situational awareness

The situational awareness section of the questionnaire consisted of 6 objective questions (#26-31). In the first five questions, the respondents were asked to indicate whether they "Strongly disagree" (coded as 1) or "Strongly agree" (coded as 5) with the question statement. The middle position was marked as "Neutral." The last objective question took a different format, as described below. One additional question was subjective and open-ended, requesting aviator suggestions on changes to the visual displays/instruments that might improve situation awareness. The following sections summarize the data responses.

Analysis

Figure 5 plots the distributions of responses for each question dealing with situational awareness. Each bar plot contains data from both aircraft types for a specific question. The responses of five of the six questions differed significantly between the AH-64A and the AH-64D pilots.

Question 26 asked pilots if they agreed that the visual displays/instruments helped maintain awareness of the aircraft relative to the flight environment. The opinions of pilots in the AH-64A versus the AH-64D aircraft were dissimilar ($U=7027.5$, $p=0.000$). As Figure 5 indicates, while both pilot groups tended to agree with this statement, the AH-64D pilots had a higher percentage of responses on the "agree" side of the scale. Among the AH-64D pilots, 73% of the responses were on the agree side of the scale, while only 43% of the AH-64A pilots chose such responses.

Question 27 asked pilots if they agreed that the visual displays/instruments promoted an appropriate allocation of time spent inside and outside the aircraft. Any differences in ratings across aircraft were not statistically significant ($U=9905.0$, $p=0.331$). As Figure 5 indicates, both sets of pilots had responses that were spread across the middle three choices of the scale.

Question 28 asked pilots if they agreed that the visual displays/instruments allowed access to all the information that was needed. The opinions of pilots in the AH-64A versus the AH-64D aircraft were dissimilar ($U=4508.0$, $p=0.000$). As Figure 5 indicates, the responses of the AH-64A pilots were largely in the middle of the scale, while the responses of the AH-64D pilots

were almost entirely on the “agree” side of the scale. Among the AH-64D pilots, 81% of the responses were on the agree side of the scale, while only 33% of the AH-64A pilots chose such responses.

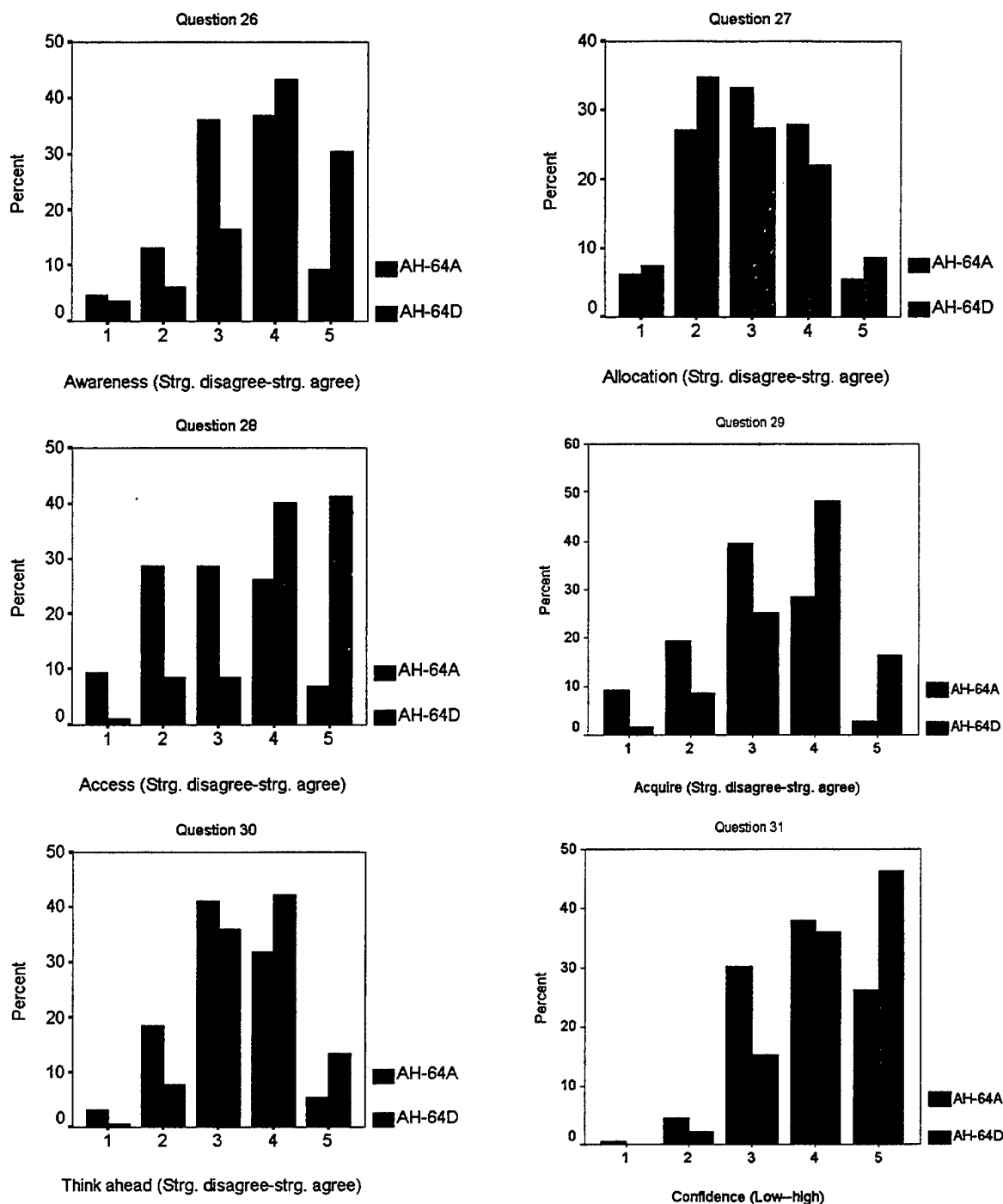


Figure 5. Responses for questions 26-31 on situational awareness. Responses for the AH-64A pilots are in red (dark gray) and responses for the AH-64D pilots are in green (light gray).

Question 29 asked pilots if they agreed that the visual displays/instruments allowed them to get the information they need within an appropriate amount of time. The opinions of pilots in the AH-64A versus the AH-64D aircraft were dissimilar ($U=6390.0$, $p=0.000$). As Figure 5 indicates, the responses of the AH-64A pilots were largely in the middle of the scale, while the AH-64D pilots had more responses on the “agree” side of the scale. Among the AH-64D pilots, 64% of the responses were on the agree side of the scale, while only 32% of the AH-64A pilots chose such responses.

Question 30 asked pilots if they agreed that the visual displays/instruments allows them to think-ahead of the aircraft. The opinions of pilots in the AH-64A versus the AH-64D aircraft were dissimilar ($U=7966.0$, $p=0.000$). As Figure 5 indicates, the AH-64A pilots had a slight bias for agreeing, but the AH-64D had a very strong bias for “Strongly agree” side of the scale. Among the AH-64D pilots, 55% of the responses were on the agree side of the scale, while only 37% of the AH-64A pilots chose such responses.

Question 31 asked pilots to report how much confidence they placed in the accuracy of the information shown in the visual displays/instruments. The scale was marked by “Low” (coded as 1) to “High” (coded as 5) with “Medium” (coded as 3) in the middle of the scale. The opinions of pilots in different aircraft were different ($U=7806.0$, $p=0.000$). As Figure 5 indicates, for both groups, the reports were almost all in the medium to high range. However, the AH-64D pilots gave more reports of high confidence and fewer reports of medium confidence than the AH-64A pilots. Among the AH-64D pilots, 82% of the responses were on the agree side of the scale, while only 58% of the AH-64A pilots chose such responses.

Respondent comments

Many of the comments made by the AH-64A pilots were similar to those generated in response to the workload question. One new response was a request for a moving map display. Representative comments of the AH-64A pilots were:

- Adding a single visual display console with a selectable moving map and TQ and turn slip and HOD [head out display] greatly improve operations in the front seat.
- Once again I think most of the problems associated with the A model Apache has been corrected. I would like to see a moving map display to improve situational awareness.
- The AH-64A is a bad design and should be completely re-designed.

All of the comments are detailed in Appendix B.

Like the AH-64A pilots, many AH-64D pilots requested a moving map. Other comments also noted that the MFDs tend to make the pilot focus inside the aircraft and that the paging system often required too many button pushes. Representative comments of the AH-64D pilots were:

- Too many menus/screen. Actions that used to take only the push of a button now take longer since we are forced to navigate through multiple "pages."
- Seems both crew members can get sucked into the MPDs and nobody looking outside. "SA" training can counter this.
- MPDs promote more time inside the cockpit. In my 1-6 hr flight yesterday, I was probably outside for 0.2.
- Moving map underlay with elevation data, real-time emitter download from an external source with LDS [liquid display screen] information displayed.

All of the comments are provided in Appendix B.

Conclusions

The analysis provides a clear indication that pilots flying the AH-64D believe the visual displays/instruments in their aircraft contributes more to good situational awareness than the pilots flying the AH-64A believe the visual displays/instruments in their aircraft contributes to good situational awareness.

Training

The training section of the questionnaire consisted of 3 objective questions (#33-35). One additional question was subjective and open-ended, requesting aviator suggestions on changes to the visual displays/instruments or the AQC training that might improve learning to work with the visual displays/instruments. The following sections summarize the data responses.

Analysis

Figure 6 plots the distributions of responses for questions 33 and 35 that deal with training. Each bar plot contains data from both aircraft types for a specific question. Figure 7 shows responses for question 34, which was in a different format.

Question 33 asked pilots to rate the difficulty of learning to perform tasks with the visual displays/instruments. The scale ran from "Very easy" (coded as 1) to "Very difficult" (coded as 5), with "About right" anchoring the middle of the scale. Any differences in ratings across aircraft were not statistically significant ($U=10019.5$, $p=0.721$). As Figure 6 (top) indicates, both pilot groups tended to believe the training was "About right" or one step toward the "difficult" side of the scale.

Question 35 asked pilots how much of a proficiency drop (due to absence from the aircraft) might be due to lack of practice with the visual displays/instruments. The scale ran from "Very little" (coded as a 1) to "Very much" (coded as a 5). The opinions of pilots in the AH-64A versus the AH-64D aircraft were dissimilar ($U=7616.5$, $p=0.001$). As Figure 6 indicates, responses from both sets of pilots were largely on the "Very much" side of the scale. However, the AH-64D pilots had more responses toward the extreme of the "Very much" side of the scale. Among

the AH-64D pilots, 76% of the responses were on the very much side of the scale, while only 54% of the AH-64A pilots chose such responses.

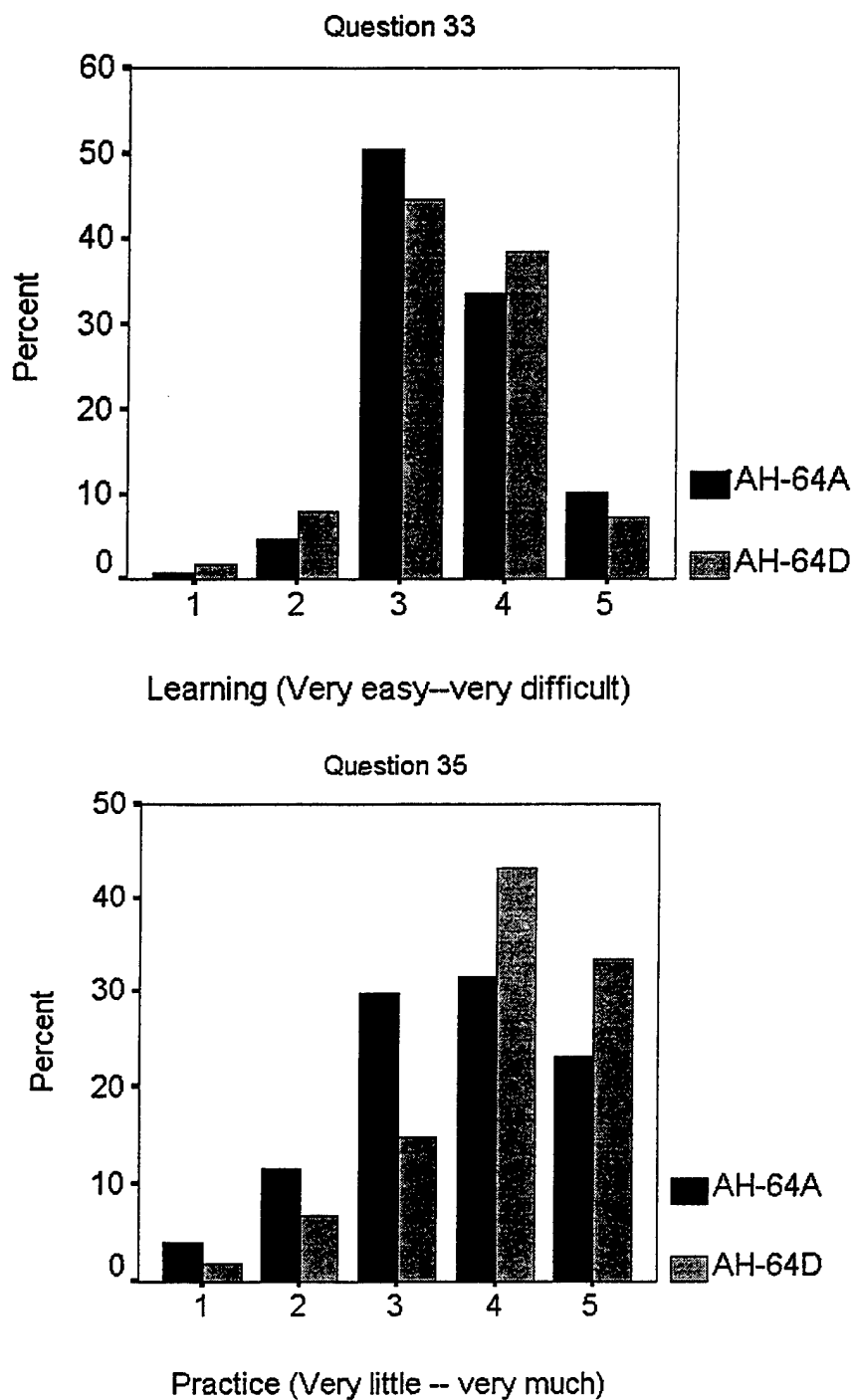


Figure 6. Responses for questions 33 and 35 on training. Responses for the AH-64A pilots are in red (dark gray) and responses for the AH-64D pilots are in green (light gray).

Question 34 asked pilots to rank order the relative importance of factors that might influence their learning to use the visual displays/instruments with 1 indicating the most important, 2 the second most important, and so on. Participants were to leave blank any components they felt did not apply. Figure 7 shows the mean rankings of various training components. The properties of many of these components are self-evident, however, a few may need additional description. The computer component refers to various training programs that are available to pilots to practice interacting with the computers in the aircraft. The conversation during AQC and conversation after AQC components refer to discussions pilots might have amongst themselves about how to use the aircraft. The graph is broken down to allow comparison of the mean rankings generated by the AH-64A and AH-64D pilots. The mean rankings are similar across aircraft type. Training flights and simulator time were listed as the two most important components (with different ordering) for each aircraft type. Likewise, conversations during and after AQC were listed as the least important components for each aircraft type. However, there were differences as well. A Mann-Whitney test for each of the components found significant differences in the rankings of the role of the computer ($U=4835.5$, $p=0.000$), the simulator ($U=6969.0$, $p=0.01$), and conversations during AQC ($U=5599.5$, $p=0.002$). Differences were not statistically significant for classroom ($U=8171.0$, $p=0.739$), mock-up ($U=4577.5$, $p=0.28$), training flights ($U=8274.5$, $p=0.140$), operational flights ($U=4969.5$, $p=0.080$), and conversations after AQC ($U=4974.0$, $p=0.325$).

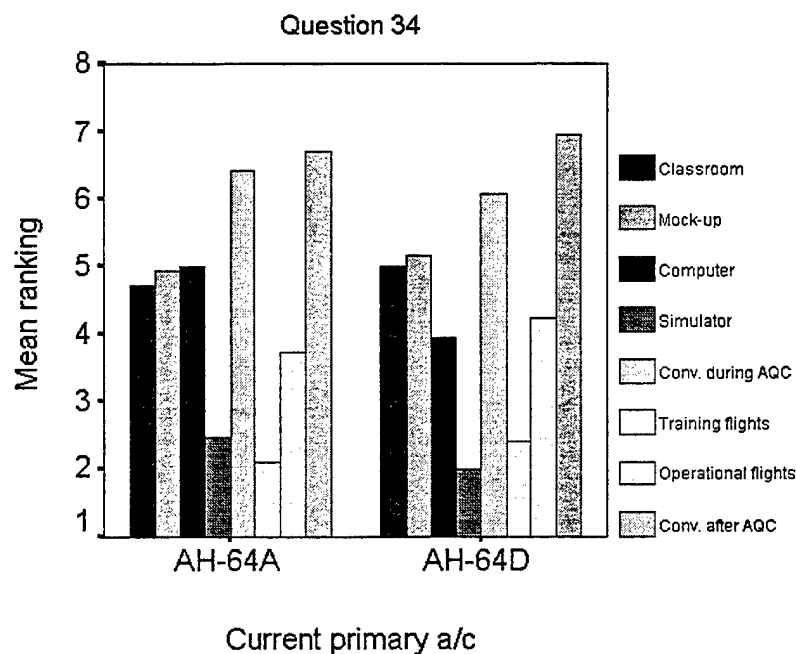


Figure 7. Responses for question 34 regarding the importance of various factors on learning to use the visual displays/instruments.

Respondent comments

The AH-64A pilots suggested having more flight time in the aircraft and more time with up-to-date computer software. Representative comments of the AH-64A pilots were:

- Use of dynamic computer displays in the classroom. We are using power point presentation in the classroom showing how instruments look during malfunction however, the slides are not animated and have very limited utility.
- Computer simulations at home on personal PC.
- More flight time during and after AQC.
- Best thing that can be done in my opinion is update the CMS [combat mission simulator] for all AH-64A i.e., CDU [Computer display unit] functions.

All of the comments are detailed in Appendix B.

Even more so than the AH-64A pilots, the AH-64D comments asked for an accurate computer simulator or emulator. Representative comments of the AH-64D pilots were:

- We badly need an updated emulator that will work reliably on newer computers, and much greater access to the LCTs [Longbow crew trainer].
- Need a TSTT [TAD (target acquisition designation system) selected task trainer] type device to practice all MPD ops which include grip and ORT buttons/switches.
- Have an MPD computer program in the learning center. Create a Longbow TSTT. Have more LCT time, get rid of supplemental course.
- Better, more accurate home computer emulators, or something in the way of a C-WEPT [Cockpit weapons emergency procedure trainer] type device that students can use without having an IP [instructor pilot] there.
- Need to have a mock up for blind cockpit procedures. Split LCT (SIM) periods so they are not back to back to allow discussion. Increase flight line flights to 2.0 instead of 1.4 to allow more interactions of tasks in the A/C [aircraft].

All of the comments are provided in Appendix B.

Conclusions

Although there were no differences in responses on the difficulty of training, pilots in the AH-64D more strongly believe that practice with the visual displays/instruments contributes to maintaining proficiency in flying the aircraft.

It is not surprising that the most important components of training involved time in the aircraft or simulator. However, the most significant training component is the difference in the role of computers across aircraft types. The AH-64D pilots ranked this as the third most important component, while the AH-64A pilots ranked it as the sixth most important component. This difference no doubt reflects the importance of learning the information structure of the MFD in the AH-64D.

Overall

One final set of questions asked pilots to comment on the introduction of MFDs in rotary-wing aircraft (Figure 8). The scale ran from “A bad idea” (coded as 1) to “A good idea” (coded as 5), with “Neutral” marking the middle of the scale. In addition, an option of “No opinion” was available. The following sections summarize the data responses.

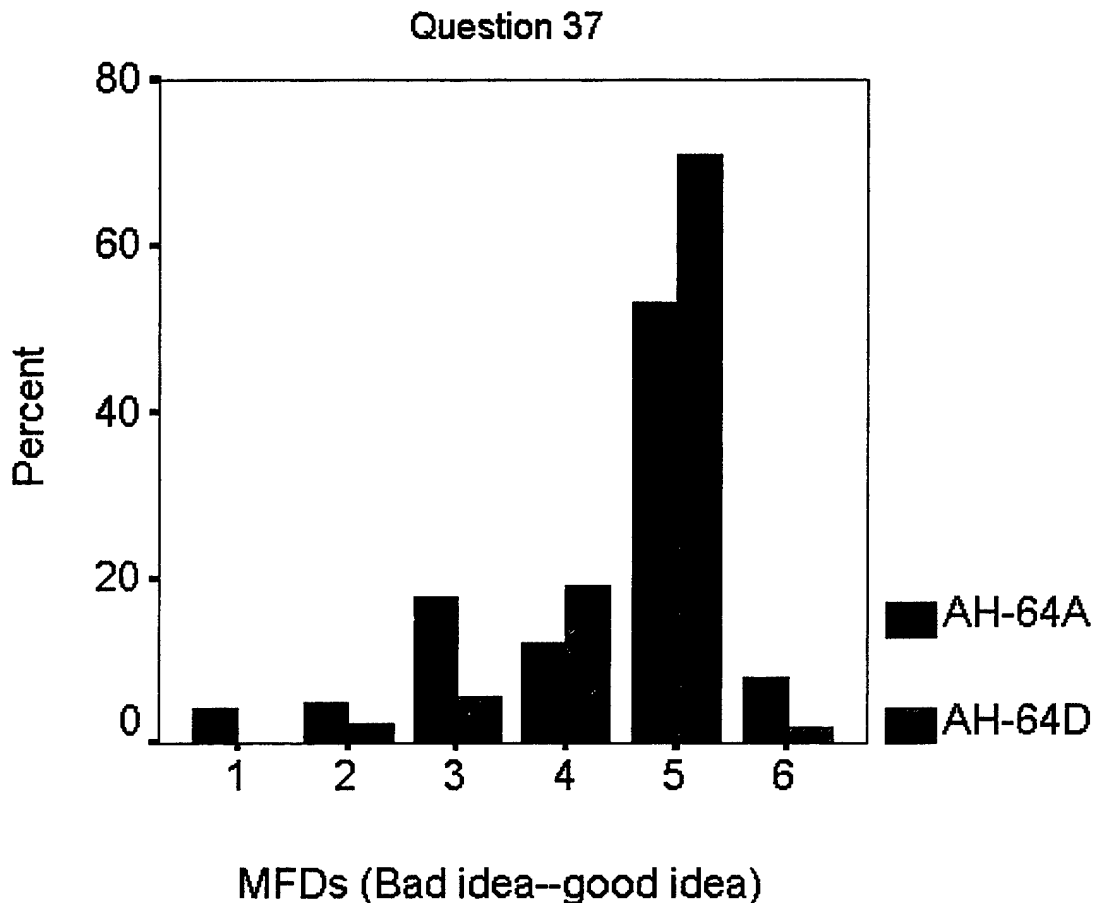


Figure 8. Responses for question 37 on overall inclusion of MFDs. Responses for the AH-64A pilots are in red (dark gray) and responses for the AH-64D pilots are in green (light gray). A response of 6 indicates no opinion.

Analysis

Figure 8 plots the distributions of responses for question 37. The differences in ratings across aircraft just missed statistical significance ($U=8973.5$, $p=0.059$). Most pilots in both groups believe the introduction of MFDs into rotary-wing aircraft is a good idea. In our data set, this tendency was perhaps a bit stronger among the AH-64D pilots than the AH-64A pilots.

Respondent comments

There were no comments from any of the pilots. This probably reflects the position of this question in the survey. After answering several other questions in some depth, pilots did not feel it necessary to comment on anything else.

Conclusions

The responses to this question were some of the most focused on the entire questionnaire. There is no question that pilots in both aircraft look favorably on the use of MFDs in the Army's rotary-wing aircraft.

Multifunction display details

Previous investigations of aircraft accident rates suggested higher accident rates for glass cockpit crewstation designs (Rash et al., 2001). Previous research (e.g., Reardon and Francis, 1999) and discussions with some pilots suggested that interacting with the MFDs could be a difficult and confusing task. Therefore, an additional set of questions was added to the survey asking pilots for their opinion about various aspects of the MFDs in their aircraft. These questions were asked only of the AH-64D pilots.

Analysis

Figure 9 plots the distributions of responses for question 39, which asked the pilots to rate various physical features of the MFDs on a scale that ran from "Poor" (coded as 1) to "Excellent" (coded as 5). The questions asked pilots to rate the following features: number of buttons, size of buttons, spacing of buttons, range of brightness and contrast controls, daytime screen visibility, nighttime screen visibility, screen visibility in the presence of internal reflections, location of MFDs for visibility, and location of MFDs for reach. The distributions of responses were favorable. Almost all pilots rated the physical features of the MFDs in the middle or toward the "Excellent" end of the scale.

Figure 10 plots the distributions of responses for question 40, which asked the pilots to rate various aspects of the information content provided by the MFDs on a scale that ran from "Poor" (coded as 1) to "Excellent" (coded as 5). The questions asked pilots to rate the following features: overall amount of information available, organization of information across pages, ease of obtaining needed information, layout of information on the screen, and customizability of information presentation. The distributions of responses were favorable. Almost all the pilots rated the properties of information content of the MFDs in the middle or toward the "Excellent" end of the scale.

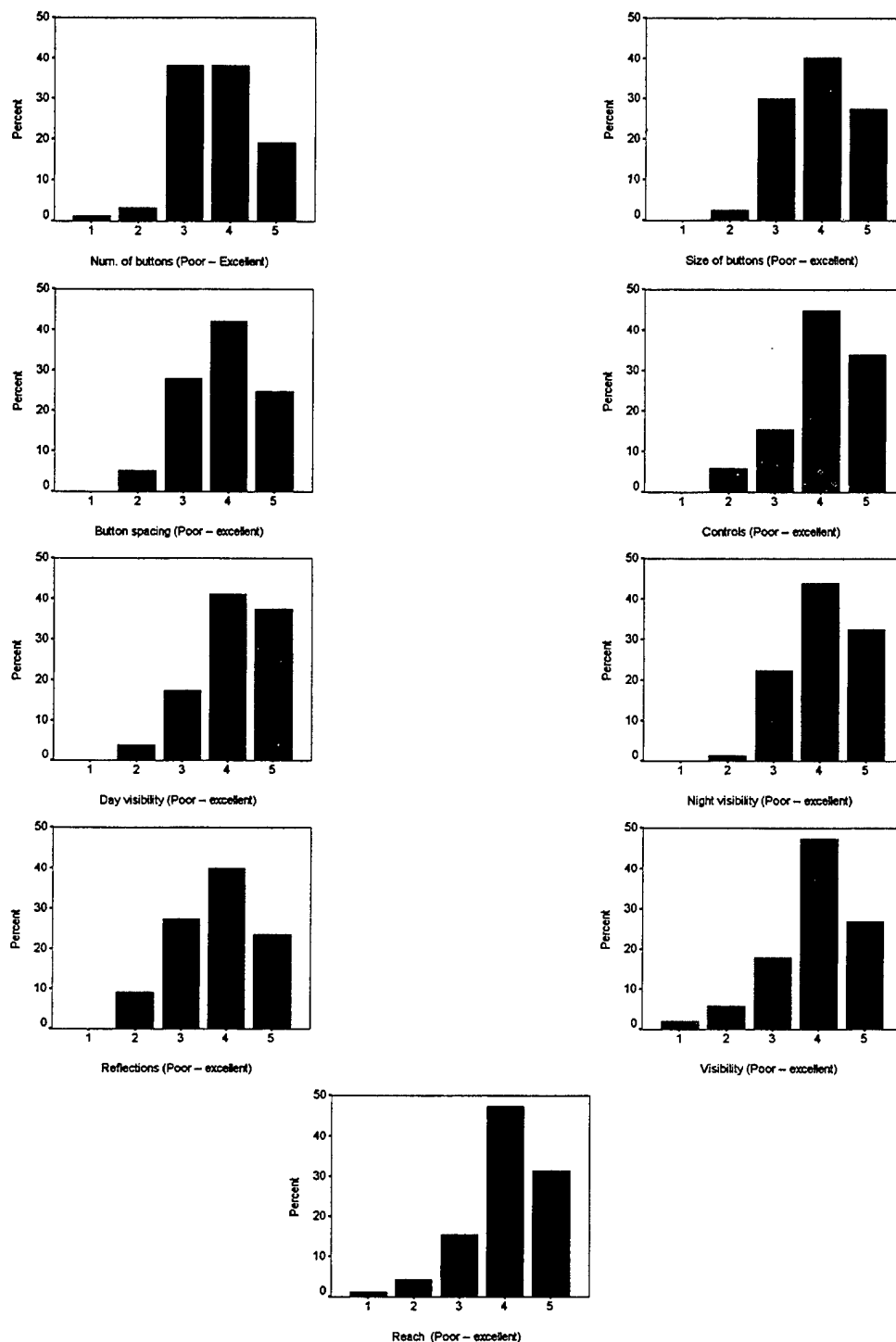


Figure 9. Responses to question 39 about the physical features of MFDs in the AH-64D aircraft. Only the AH-64D pilots were asked these questions.

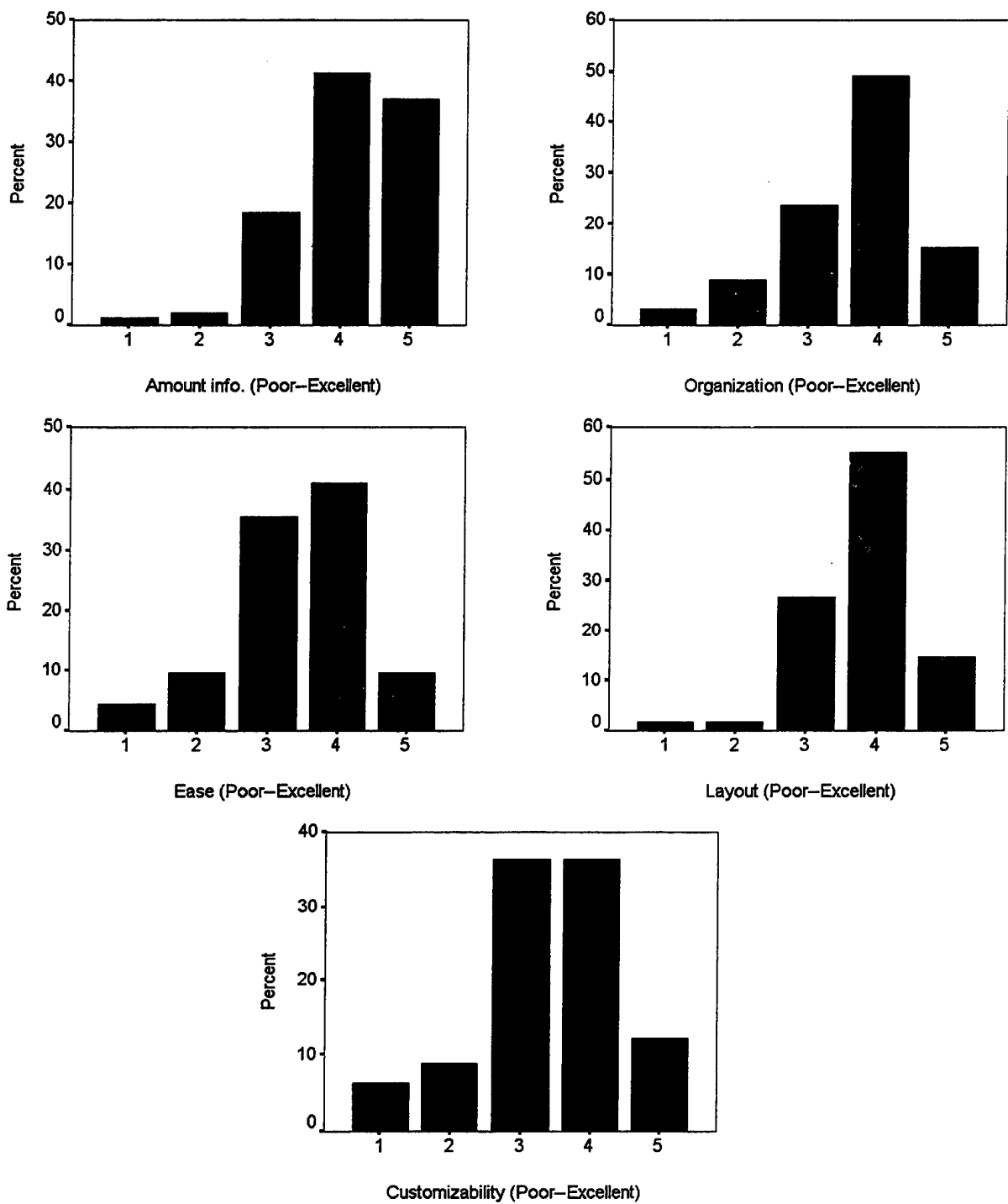


Figure 10. Responses to question 40 about the information content provided by the MFD. Only the AH-64D pilots were asked these questions.

Figure 11 plots the distributions of responses for question 41, which asked the pilots to rate the frequency of events related to accessing information from the MFD on a scale that ran from “Never” (coded as 1) to “Always” (coded as 5). Four types of events were rated: “Without looking at the MFD, you know what page you are currently on,” “When you know what information you want, you *immediately* know which page you need,” “When you know which page you need, you *immediately* know how to get to that page,” and “When the MFD displays the page you need, you *immediately* know where the desired information is located on the screen.” The responses were more toward the middle than for the other questions about MFD properties. Even so, more answers were on the “Always” side of the scale than on the “Never” side of the scale, indicating that pilots believe they have good knowledge about how to interact with the MFD.

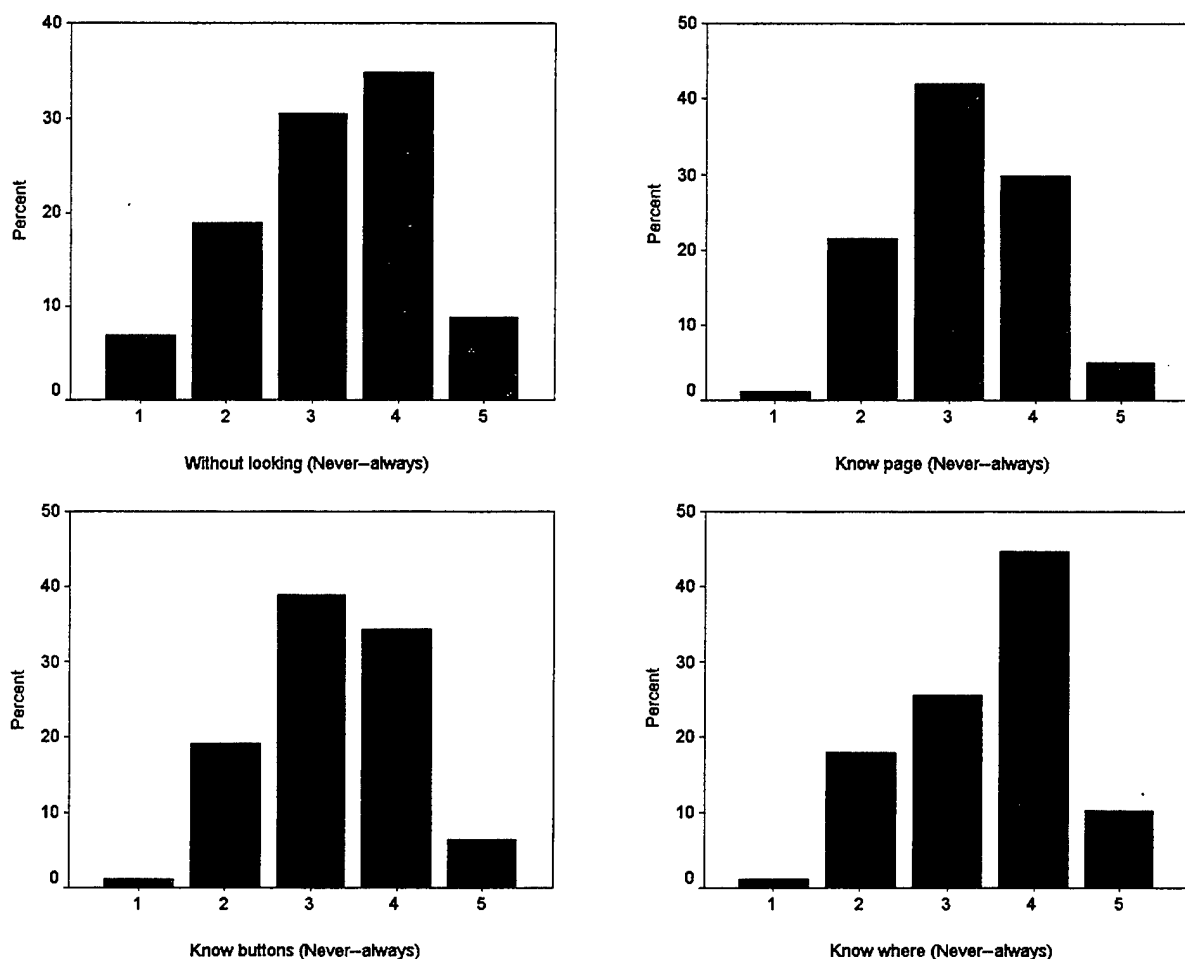


Figure 11. Responses to question 41 about working with the MFD. Only the AH-64D pilots were asked these questions.

Respondent comments

There were no comments from any of the pilots. This probably reflects the position of this question in the survey. After answering several other questions in some depth, pilots did not feel it necessary to comment on anything else.

Conclusions

The data suggests that AH-64D pilots have quite favorable opinions of the design characteristics of the MFDs. The ratings were quite high for both the physical features of the MFDs and the information content of the MFDs. The ratings were not quite as high for questions about working with the MFDs, but the ratings were still skewed to a desirable end of the scale.

Transition from traditional to glass cockpit model

The final set of questions (43-44) asked pilots of the AH-64D who had transitioned from the AH-64A model to rate the transition process and to compare the two aircraft across a variety of factors. We felt that these pilots might have a special viewpoint on the potential positives and negatives of each aircraft and could give an impression of the aircraft's overall acceptability.

Analysis

Figure 12 plots the distributions of responses for question 43, which asked the pilots to rate whether the transition between models with regard to the visual displays/instruments was "Very difficult" (coded as 1) or "Very easy" (coded as 5). There was a slight bias for responses to be on the difficult side of the scale.

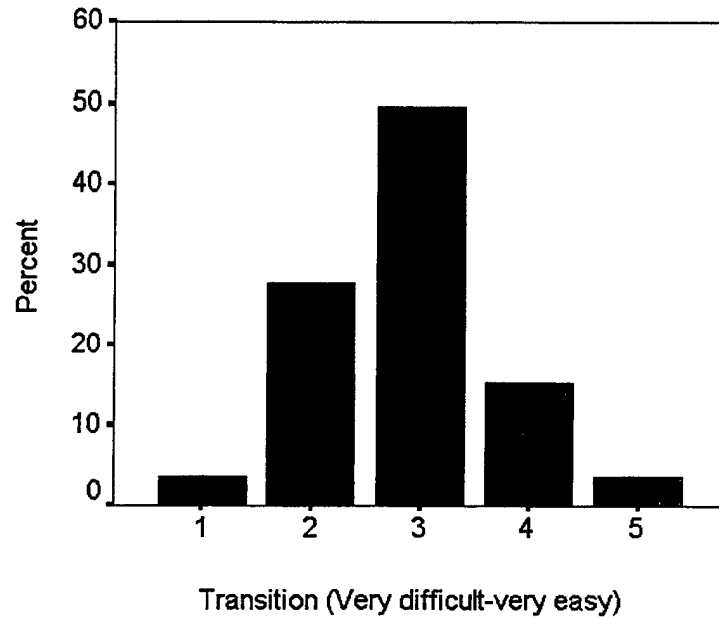


Figure 12. Responses to question 43 about the transition from the A-model to the D-model. Only the AH-64D pilots who transitioned from the A-model were asked this question.

Figure 13 plots the distributions of responses for question 44, which asked the pilots to choose between the traditional and glass cockpit aircraft in response to a sequence of questions. The rating scale ran from “Definitely tradition” (coded as 1) to “Definitely glass” (coded as 5).

Responses were fairly balanced between the traditional and glass cockpit models for questions “Which model of aircraft is safer?” and “Which model of aircraft has lower workloads?” The response to safety probably reflects the relatively low accident rate believed to exist by pilots of both types of aircraft. The workload question probably reflects the finding that across pilots in the different aircraft models, workload is perceived to be high.

Responses were clearly biased toward the traditional cockpit design for the question “Which model of aircraft is easier to learn?” Nearly 80% of the responses were in the middle of the scale or on the “traditional” side of the scale. This result is somewhat surprising because the attitude of pilots across aircraft crewstation types did not differ with regard to the difficulty of training (question 33, see Figure 6).

All of the remaining responses were clearly biased toward the glass cockpit design. This includes questions on “Which model of aircraft would you prefer to fly?,” “Which model of aircraft promotes better crew coordination?,” “Which model of aircraft promotes better awareness of the aircraft in the flight environment?,” “Which model of aircraft promotes better awareness of the aircraft’s status?,” and “Which model of aircraft better allows you to perform you missions?” The results here are unambiguous. Pilots who have transitioned from the AH-64A to the AH-64D believe the visual displays/instruments in the AH-64D result in a better aircraft.

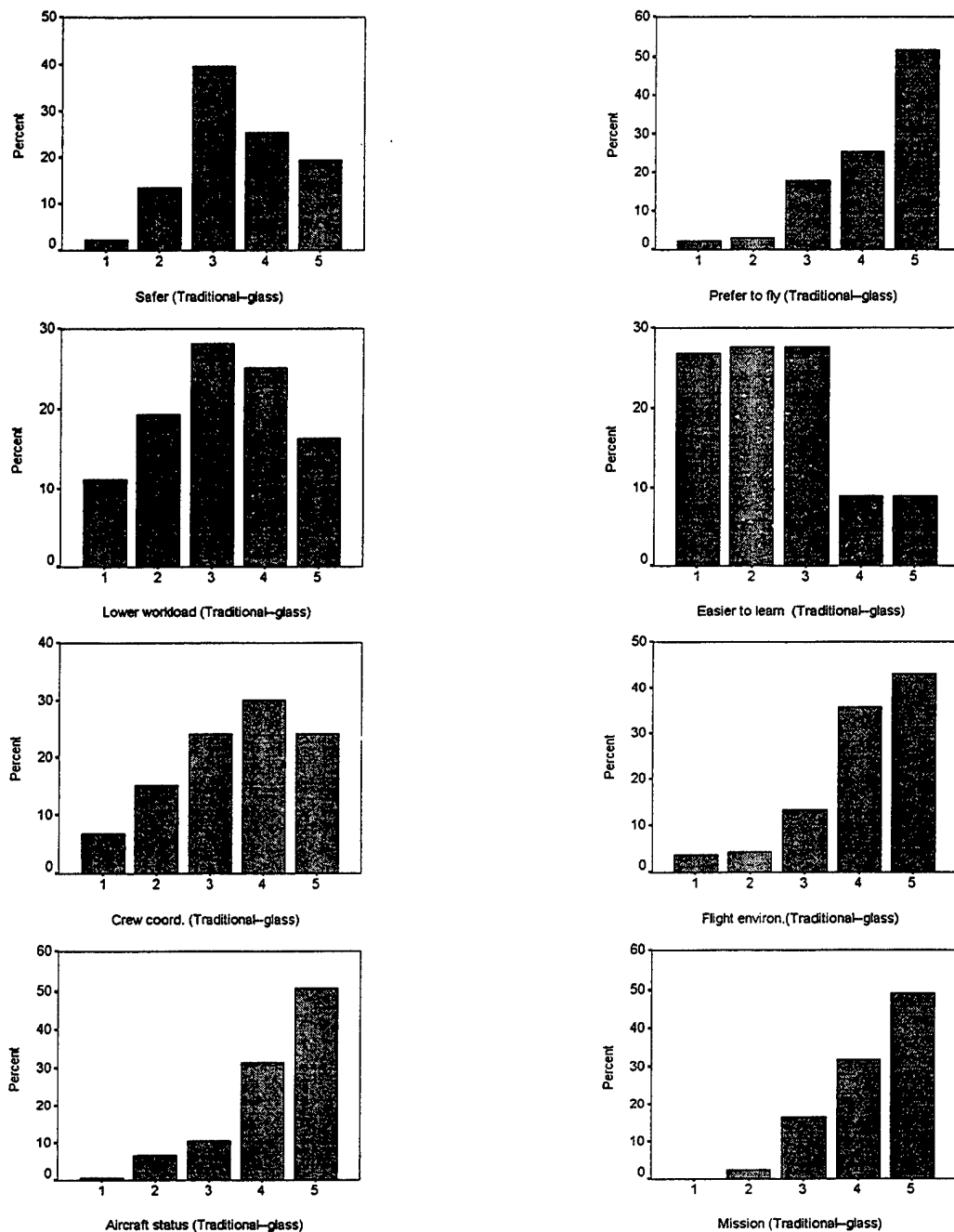


Figure 13. Responses from question 44 comparing the aircraft with different crewstation designs. Only the AH-64D pilots who had transitioned from the A-model were asked this question.

Respondent comments

Comments generally asked for additional time and opportunities for training. Many respondents also suggested that if the survey was repeated a year from now (when they have gone through more training) the answers would be very different. Representative comments of the AH-64D pilots were:

- More MPD training on the hierarchy of how the pages flow. If you know how to get to a page quickly, the MPD tells you what to do there.
- Should have backup instruments in front seat. More training should be available, more flight hours.
- Repetition is the key to success. The more times you perform a given task, the easier it becomes.
- Let me take this survey one year from now. Answers will be different because of higher experience level.
- We are very new to the AH-64D, our interaction with it and the various systems is what is completely new to us. After flying and some experience in the cockpit. Push-in buttons and learning how to crew coordinate actions and employing the machine.

All of the comments are provided in Appendix B.

Conclusions

The pilot's responses strongly favor the glass cockpit aircraft. The only question where the traditional aircraft had an advantage was with regard to learning to use the visual displays/instruments. Among those pilots who have transitioned from the traditional to the glass cockpit version of the AH-64 aircraft, clearly the pilots' preference is for the glass cockpit model.

Conclusions

This study was motivated by the recent finding (Rash et al., 2001) that some U. S. Army rotary-wing aircraft with glass cockpit crewstation designs have higher accident rates than corresponding aircraft with a traditional crewstation design. As Rash et al. (2001) noted, there may be many reasons for the difference in accident rates. The current study was designed to try to identify factors that may be related to the accident rate data. By asking pilots for their opinion on the visual displays and instruments in their aircraft as they relate to a number of issues, we hoped to identify how the accident rate and the type of cockpit design might be related.

It should be stated explicitly that the accident rates in the AH-64 followed the trend of most aircraft where the AH-64D glass cockpit model had a higher accident rate (22.44) than the AH-64A traditional cockpit model accident rate (17.16). However, because there were relatively few flight hours for the AH-64D, this difference did not reach statistical significance. Even so, the difference in the accident rate is worth watching, and a planned repeat of the study by Rash et al. (2001) will follow up on the AH-64 when sufficient flight hours are available. The results of the questionnaire study will help to fine-tune further accident data analyses.

Moreover, one of the justifications for introducing glass cockpit designs is that they improve safety. Indeed, this is certainly true in commercial aircraft, where aircraft with glass cockpit crewstations are much safer than aircraft with traditional instruments. Thus, the lack of a statistical difference in accident rates in favor of the traditional crewstation is somewhat unexpected. The attitudes of pilots toward the crewstation designs may help explain why the expected improvement in safety has not occurred.

One clear conclusion from this study is that pilots prefer the glass cockpit design in the AH-64D compared to the traditional crewstation design in the AH-64A. The vast majority of questions show that the AH-64D pilots have a better opinion of their glass crewstation design than the AH-64A pilots have of their traditional crewstation design. To account for the higher accident rate in the AH-64D, we need to focus on the few situations where the data suggest that the AH-64D design might impair flight performance: mental workload and maintaining proficiency.

On the workload question (#9), the AH-64D pilots' report of their overall mental activity is higher than the report from the AH-64A pilots. Significantly, subsequent questions on topics related to workload either favored the AH-64D or showed no difference. This is somewhat of a surprising finding. One of the advantages of the glass cockpit design is that information can be presented in a variety of formats that should allow easier understanding. If this is happening in the current displays, it is apparently being offset by some other mental activity. That other activity is not likely to be difficulty navigating the MFD because pilots report satisfaction with that aspect of the crewstation design (question 41, see Figure 11). Perhaps the difference in opinion reflects the increased capabilities and tasks of the AH-64D versus the AH-64A.

There were also differences in reports regarding practice and maintaining proficiency (question 35). The AH-64D pilots indicated that lack of practice with the displays and instruments contributed to a drop in flying proficiency after an absence from the aircraft. In contrast, the AH-64A pilots did not have so strong an opinion. Likewise, the rankings of the importance of training components (question 34) were biased among the AH-64D pilots to those components that involve practice with the visual displays and instruments. Partially consistent with this finding, those AH-64D pilots who transitioned from the AH-64A to the AH-64D reported that the AH-64A model was much easier to learn (question 44). This is only partially consistent because when AH-64A and AH-64D pilots were asked to characterize learning to perform tasks with the visual displays/instruments (question 33), there was no difference across aircraft type.

Nevertheless, the bulk of the responses suggest that pilots find the glass cockpit design of the AH-64D more difficult to learn and to maintain proficiency than the traditional cockpit design of the AH-64A. The reports of higher mental workload among AH-64D pilots may be related to the training and proficiency issues.

While it is believable that difficulties in training, proficiency, and mental workload among the AH-64D pilots might contribute to safety issues, more study is required to make such a causal link. If it exists, we expect the link should be a strong one. We believe this because the pilots clearly approve of many other characteristics of the glass cockpit design. According to the opinions of the AH-64 pilots in this survey, the glass cockpit design provides better control of issues on workload, situation awareness, safety, crew coordination, situation awareness, and are overall a good idea for U. S. Army rotary-wing aircraft. The opinions on these issues were all quite strong.

Despite these strong favorable opinions, the properties of the AH-64D model have not led to a corresponding decrease in the accident rate relative to the AH-64A model. If there is any difference in accident rates, it is that the AH-64D aircraft has a higher rate. Some factors must be working against the favorable properties of the glass cockpit aircraft. If the unfavorable properties are related to learning, proficiency, and mental workload, then they must have quite strong effects to counter the beneficial aspects of the glass cockpit design.

It should be noted that, while the AH-64A and AH-64D aircraft have the same aerodynamics, the AH-64D has an expanded set of capabilities and missions. It is possible that the accident rate for the AH-64D is the result of these expanded capabilities and missions rather than a direct consequence of the properties of the crewstation design.

Recommendations

The results of the survey suggest that there may be difficulties in training and maintaining proficiency of use with the glass cockpit design in the AH-64D. Rash et al. (2001) recommended a follow-up study of the accident rate data when sufficient flight hours became available to support firmer statistical conclusions. We reiterate that recommendation and additionally recommend that when the follow-up accident rate data study is carried out, it should look for a link between the frequency of accidents and the likely proficiency level of the pilots involved. Proficiency level would include total flight hours and number of flight hours over the past 90 days. These numbers would be compared to the total flight hours and flight hours over the past 90 days from a random sample of pilots on flights without accidents. One could then compare the flight hour variables across the accident and non-accident groups to see if there is a significant difference.

In addition, we recommend that the U. S. Army improve the computer training programs for the AH-64D. Although some types of programs are currently available, the reports from pilots are that the programs are out of date and/or incomplete versions of what is actually used in the

aircraft. If such programs were up to date and available for use on a home computer, a pilot could maintain proficiency even while away from the aircraft.

References

- Bell Helicopter Textron Inc. 1988. OH-58D - A U.S. Army scout with eye-opening technology. Also see the web site at: <http://www.belltexttron.com/content/products/MilitaryHelicopters/oh58d/productBrochure/features.html>
- Bender, G. L., Mitchell, E. L., Kimberly, J. L., and Sharon, G. A. 1984. Preliminary airworthiness evaluation (PAE) of the OH-58D helicopter (AHIP). Edwards Air Force Base, California U. S. Army Aviation Engineering Flight Activity. USAAEFA Project No. 83-26.
- Clason, D. L., and Dormody, T. J. 1994. Analyzing data measured by individual Likert-scale items. Journal of Agricultural Education, Vol. 35, No. 4, 31-35.
- Degani, A., Chappell, S. L., and Hayes, M. S. 1991. Who or what saved the day? A comparison of traditional and glass cockpits. In R. S. Jensen (Ed.), Proceeding of the Sixth International Symposium on Aviation Psychology Conference. 227-234.: Ohio State University. Columbus, OH.
- Department of Defense. 1992. Aircrew coordination exportable training package: Student guide. United States Army Aviation Center, Fort Rucker, Alabama.
- Funk, K. and Lyall, B. 1997. Flight Deck Automation Issues. Web page sponsored by the Federal Aviation Administration . <http://flightdeck.ie.orst.edu/FDAI/issues.html>
- Gregoire, T. G., and Driver, B. L. 1987. Analysis of ordinal data to detect population differences. Psychological Bulletin, 101 (1), 159-165.
- Hamilton, D. B., Bierbaum, C. R., and McAnulty, D. M. 1994. Operator task analysis and work load prediction model of the AH-64D mission. Volume I: Summary report. Aberdeen Proving Ground, Maryland, U. S. Army Research Laboratory. ARL-CR-147
- Hart, S. G., and Staveland., L. E. 1988. Development of a multi-dimensional workload rating scale: Results of empirical and theoretical research. In P. A. Hancock & N. Meshkati (Eds.), Human Mental Workload. Amsterdam. The Netherlands: Elsevier.
- Ramsey, B. and Altman, B. 1998. Spotlight: OH-58D safety performance review, Flightfax, October, Vol. 26, No.13. Fort Rucker, AL: U. S. Safety Center, October.
- Rash, C. E., Suggs, C. L., Leduc, P. A., Adam, G. E., Manning, S. D., Francis, G., and Nobak, R. 2001. Accident rates in glass cockpit model U. S. Army rotary-wing aircraft. Fort Rucker, AL: U. S. Army Aeromedical Research Laboratory. USAARL Report No. 2001-12.
- Sarter, N.B. and Woods, D.D. 1995. How in the world did we ever get into that mode? Mode error awareness in supervisory control. Human Factors, 31, 5-19.

Silverio, F. J. and Drennen, T. G. 1985. Advanced cockpits for battlefield helicopters – A Sikorsky perspective. Paper presented at the Eleventh European Rotorcraft Forum, Paper No. 14, London, England.

Taylor, R. M. 1990. Situational awareness rating technique (SART): The development of a tool for aircrew systems design. In Situational Awareness in Aerospace Operations (AGARD-CP-478; pp. 3/1-3/17). Neuilly Sur Seine, France: NATO-AGARD.

Wiener, E.L. 1989. Human factors of advanced technology ("glass cockpit") transport aircraft. Moffet Field, CA: NASA Ames Research Center. NASA CR 177528.

Wiener, E. L. and Curry, R. E. 1980. Flight-deck automation: Promises and problems. Ergonomics. **23**, 995-1011.

Appendix A.

Questionnaire: A comparison of pilot attitudes toward traditional and glass cockpits in U.S. Army rotary-wing aircraft.

This appendix includes the questions on the questionnaire and a report of the responses to those questions, broken down by pilots in different aircraft. The values in the tables are the number of times each rank was chosen by the pilots. The bar graphs in the main text converted these numbers to percentages.

Demographics

1) Please indicate your current primary aircraft. If you are currently in transition, identify your transition aircraft (select only one):

_____ OH-58A/C

_____ OH-58D

_____ AH-64A (Please indicate if primarily pilot _____, co-pilot/gunner _____, AQC _____.)

_____ AH-64D (Please indicate if primarily pilot _____, co-pilot/gunner _____, AQC _____.)

	Frequency	Pilot	Co-pilot/gunner	AQC
AH-64A	134	31	39	1
AH-64D	164	18	36	61

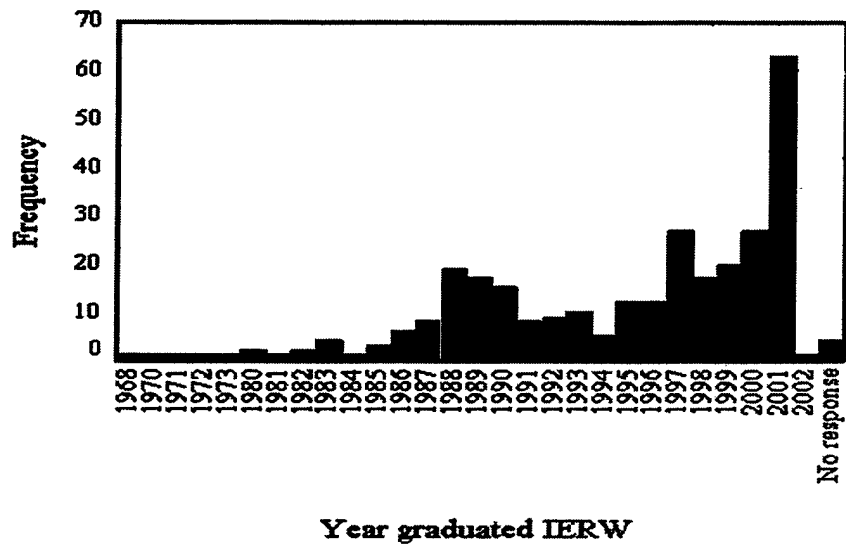
2) Age _____



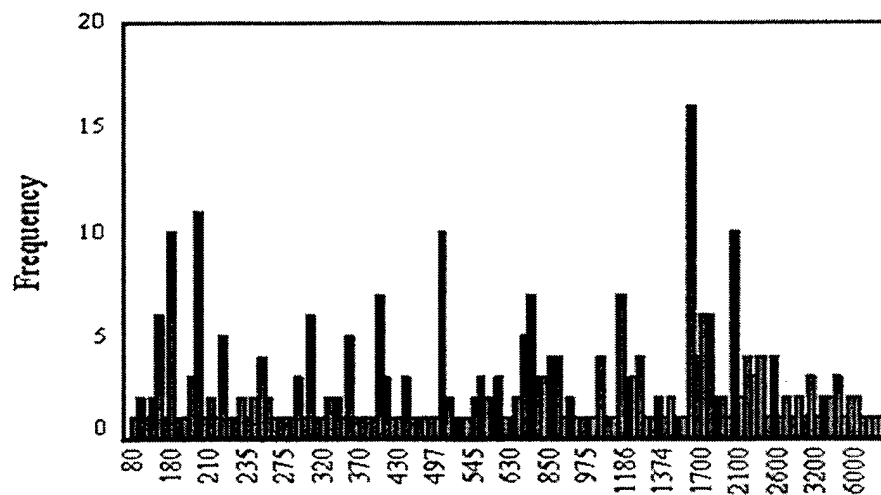
3) Sex (circle one): male female

	AH-64D	OH-58D
Male	155	165
Female	9	4

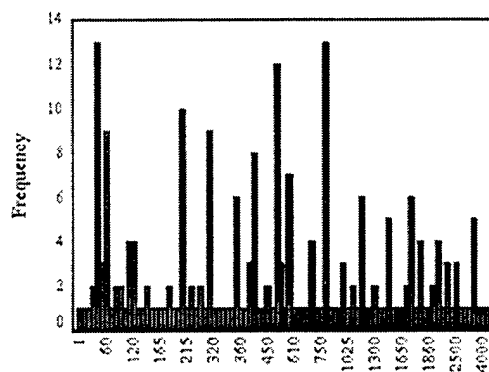
4) Year graduated IERW _____



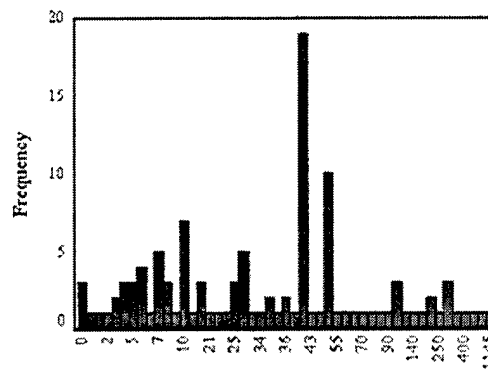
5) Total military rotary-wing aircraft flight hours _____



Total military rotary wing flight hours



Total AH-64A flight hours



Total AH-64D flight hours

6) Give aircraft flight hours for any of the following rotary-wing aircraft that you are rated in:

AH-64A AH-64D Other
 OH-58A/C OH-58D

AH-64D

	Minimum	Maximum	Mean	Median	Standard deviation
AH-64A	1	5500	687.25	350	855.073
AH-64D	0	1145	74.17	36	162.138
OH-58A/C	1	3500	166.15	75	371.921
OH-58D	5	350	158.67	70	141.5
Other	1	2000	328.84	150	441.372
OH-58D	5	350	158.67	70	141.5

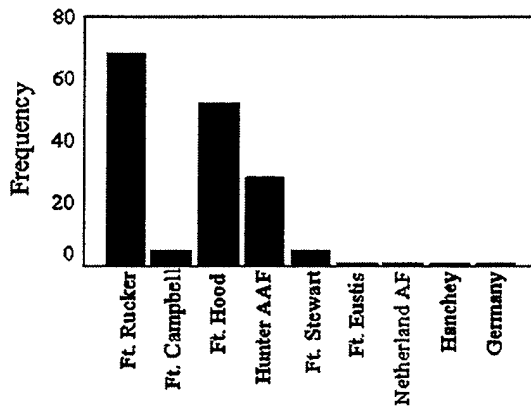
OH-58D

	Minimum	Maximum	Mean	Median	Standard deviation
AH-64A	15	75	45	45	42.426
AH-64D	0	0	0	0	0
OH-58A/C	15	5000	399.36	145	679.351
OH-58D	12	3700	879.09	700	735.090

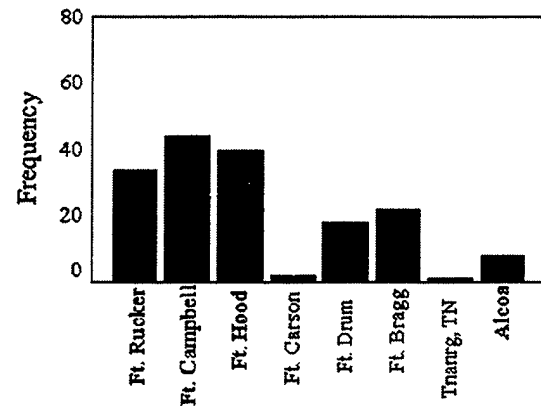
7) Please indicate your status for your primary aircraft (choose only one):

instructor pilot (IP, SIP) in an AQC line pilot
 test/maintenance pilot Other (please specify)

	Instructor pilot (IP, SIP)	Line pilot	Test/maintenance pilot	In an AQC	Other
AH-64A	56	67	3	3	5
AH-64D	17	44	12	78	9



AH-64D current unit location



OH-58D current unit location

Workload

9) Characterize the amount of overall mental activity (e.g., thinking, deciding, calculating, remembering, searching) required to work with the visual displays/instruments.

1	2	3	4	5
Very little				Very much

	1	2	3	4	5
AH-64A	6	21	53	40	13
AH-64D	4	11	56	65	28

10) Characterize the amount of overall physical activity (e.g., flipping switches, pushing buttons, turning dials) required to work with the visual displays/instruments.

1	2	3	4	5
Very little				Very much

	1	2	3	4	5
AH-64A	14	35	48	32	5
AH-64D	19	36	47	45	17

11) The design of the visual displays/instruments generally minimizes the amount of time required to perform tasks.

1 2 3 4 5
Strongly disagree Neutral Strongly agree

	1	2	3	4	5
AH-64A	10	35	56	28	4
AH-64D	4	32	46	66	15

12) The design of the visual displays/instruments is frustrating.

1 2 3 4 5
Strongly disagree Neutral Strongly agree

	1	2	3	4	5
AH-64A	11	34	52	26	11
AH-64D	24	70	44	23	3

13) The design of the visual displays/instruments keeps me busier than I think I need to be.

1 2 3 4 5
Strongly disagree Neutral Strongly agree

	1	2	3	4	5
AH-64A	13	25	54	34	8
AH-64D	18	55	56	28	6

14) The workload in my aircraft, as it relates to using the visual displays/instruments, is:

1 2 3 4 5
Too low About right Too high

	1	2	3	4	5
AH-64A	1	2	74	52	5
AH-64D	0	2	100	59	3

15) Please suggest any changes to the visual displays/instruments that might improve workload levels for this aircraft. Write any comments on the lines below.

All comments are provided in Appendix B.

Safety

16) How much do you think the design of the visual displays/instruments may contribute to accidents in your aircraft?

1 2 3 4 5
Very little About right Very much

	1	2	3	4	5
AH-64A	27	34	37	25	7
AH-64D	26	49	48	34	5

17) The Army keeps statistics on all Class A, B, and C accidents. Combined across all types of helicopters in the US Army rotary-wing fleet, there was an accident rate of 9.46 accidents for every 100,000 flight hours over the years 1996-2000. Do you think the accident rate of *your* aircraft was higher or lower than the fleet rate?

1 2 3 4 5
Much lower Same Much higher

	1	2	3	4	5
AH-64A	6	34	51	33	5
AH-64D	14	54	51	39	5

18) How much do you feel that the design of the visual displays/instruments could be improved to reduce the accident rate in your aircraft?

1 2 3 4 5
Very little About right Very much

	1	2	3	4	5
AH-64A	11	22	38	41	20
AH-64D	18	36	57	48	4

19) Please suggest any changes to the visual displays/instruments that might improve safety in your aircraft. Write any comments on the lines below.

All comments are provided in Appendix B.

Crew coordination

20) The design of the visual displays/instruments contributes to positive crew relationships with open communication.

1 2 3 4 5
Strongly disagree Neutral Strongly agree

	1	2	3	4	5
AH-64A	4	23	68	32	5
AH-64D	2	22	60	61	19

21) As the mission situation changes, the visual displays/instruments promote effective and efficient redistribution of crewmember responsibilities.

1 2 3 4 5
Strongly disagree Neutral Strongly agree

	1	2	3	4	5
AH-64A	5	28	63	32	4
AH-64D	0	14	47	77	25

22) The design of the visual displays/instruments supports the free flow of essential mission information among crewmembers.

1 2 3 4 5
Strongly disagree Neutral Strongly agree

	1	2	3	4	5
AH-64A	5	36	50	31	10
AH-64D	0	11	43	74	36

23) As crew members make actions and decisions, the visual displays/instruments promote cross-monitoring to reduce the likelihood of errors impacting mission performance and safety.

1 2 3 4 5
Strongly disagree Neutral Strongly agree

	1	2	3	4	5
AH-64A	7	32	47	35	11
AH-64D	4	22	35	84	19

24) The visual displays/instruments promote good crew coordination.

1 2 3 4 5
Strongly disagree Neutral Strongly agree

	1	2	3	4	5
AH-64A	5	34	60	32	1
AH-64D	1	27	52	58	25

25) Please suggest any changes to the visual displays/instruments that might improve crew coordination for this aircraft. Write any comments on the lines below.

All comments are provided in Appendix B.

Situational awareness

26) The visual displays/instruments help me maintain awareness of the aircraft relative to the flight environment.

1 2 3 4 5
Strongly disagree Neutral Strongly agree

	1	2	3	4	5
AH-64A	6	17	47	48	12
AH-64D	6	10	27	71	50

27) The visual displays/instruments promote an appropriate allocation of time spent "inside" and "outside" the cockpit.

1 2 3 4 5
Strongly disagree Neutral Strongly agree

	1	2	3	4	5
AH-64A	8	35	43	36	7
AH-64D	12	57	45	36	14

28) The visual displays/instruments allow me access to all the information I need.

1 2 3 4 5
Strongly disagree Neutral Strongly agree

	1	2	3	4	5
AH-64A	12	37	37	34	9
AH-64D	2	14	14	66	68

29) The visual displays/instruments allow me to acquire the information I need within an appropriate amount of time.

1 2 3 4 5
Strongly disagree Neutral Strongly agree

	1	2	3	4	5
AH-64A	12	25	51	37	4
AH-64D	3	14	41	79	27

30) The visual displays/instruments help me to "think ahead" of the aircraft.

1 2 3 4 5
Strongly disagree Neutral Strongly agree

	1	2	3	4	5
AH-64A	4	24	53	41	7
AH-64D	1	13	59	69	22

31) How much confidence do you place in the accuracy of the information displayed by your visual displays/instruments ?

1 2 3 4 5
Low Medium High

	1	2	3	4	5
AH-64A	1	6	39	49	34
AH-64D	0	4	25	59	76

32) Please suggest any changes to the visual displays/instruments that might improve situation awareness for this aircraft. Write any comments on the lines below.

All comments are provided in Appendix B.

Training

33) Learning to perform tasks with the visual displays/instruments was:

1 2 3 4 5
Very easy About right Very difficult

	1	2	3	4	5
AH-64A	1	6	63	42	13
AH-64D	3	13	73	63	12

34) Please rank the following training components involved in learning to use the visual displays/instruments. Give the number 1 to the most important component, the number 2 to the second most important component, and so on. Leave blank any components that do not apply to you.

- _____ classroom
- _____ mock-up
- _____ computer training programs
- _____ training simulator
- _____ conversation with peers *during* AQC training

- ☐ training flights
☐ operational flights after training
☐ conversation with peers *after* AQC training

	1	2	3	4	5	6	7	8
Classroom								
AH-64A	11	6	13	23	22	21	4	8
AH-64D	5	9	30	35	29	24	7	16
Mock-up								
AH-64A	0	7	18	20	18	13	10	9
AH-64D	5	7	10	20	19	15	18	13
Computer training programs								
AH-64A	3	7	14	19	19	12	9	11
AH-64D	11	21	38	41	22	7	3	9
Training simulator								
AH-64A	30	39	31	6	2	2	2	0
AH-64D	64	62	26	2	4	1	0	0
Conversation with peers during AQC training								
AH-64A	0	0	4	8	20	19	30	17
AH-64D	2	3	11	23	36	24	37	13
Training flights								
AH-64A	56	33	9	6	4	5	1	0
AH-64D	65	47	24	12	9	4	0	0
Operational flights after training								
AH-64A	16	21	18	14	11	10	8	3
AH-64D	14	16	19	16	14	23	9	3
Conversation with peers after AQC training								
AH-64A	0	2	2	12	10	12	23	36
AH-64D	1	1	0	6	10	20	30	43

35) After not flying for a while, a pilot may notice a temporary drop in proficiency flying the aircraft. How much of this drop in proficiency do you think is the result of a lack of practice with the visual displays/instruments?

1 2 3 4 5
 Very little About right Very much

	1	2	3	4	5
AH-64A	5	14	36	38	28
AH-64D	3	11	24	70	54

36) Please suggest any changes to the visual displays/instruments or AQC training that might improve learning to use the visual displays/instruments in your aircraft. Write any comments on the lines below.

All comments are provided in Appendix B.

Overall

37) In my opinion, the Army's trend to include multifunction displays into rotary-wing aircraft is:

1 2 3 4 5 OR 6
A bad idea Neutral A good idea No opinion

	1	2	3	4	5	6
AH-64A	5	6	22	15	66	10
AH-64D	0	4	9	31	116	3

38) Please use the space below to mention any other opinions you have about the visual displays/instruments or this survey. Write any comments on the lines below.

All comments are provided in Appendix B.

If your current aircraft is not an OH-58D or an AH-64D glass cockpit model and you are not in an AQC for transition to an OH-58D or an AH-64D, you have finished the questionnaire. **Thank you for your time.**

If your current aircraft is an OH-58D or an AH-64D,
or you are in an AQC for transition to an OH-58D or an
AH-64D, please answer the questions in the next section.

MFD details

(ONLY FOR D-MODEL PILOTS OR THOSE WHO ARE IN AN AQC FOR A D-MODEL!)

39) Please rate the acceptability of the following physical features of the MFDs in your aircraft:

	Poor			Excellent	
Number of buttons.....	1	2	3	4	5
Size of buttons.....	1	2	3	4	5
Spacing of buttons.....	1	2	3	4	5
Range of brightness and contrast controls.....	1	2	3	4	5
Daytime screen visibility.....	1	2	3	4	5

Nighttime screen visibility	1	2	3	4	5
Screen visibility in the presence of internal reflections.....	1	2	3	4	5
Location of MFDs for visibility.....	1	2	3	4	5
Location of MFDs for reach.....	1	2	3	4	5

	1	2	3	4	5
Number of buttons	2	5	60	60	30
Size of buttons	0	4	47	63	43
Spacing of buttons	0	3	44	66	39
Range of brightness and contrast controls	0	9	24	70	53
Daytime screen visibility	0	6	27	64	58
Nighttime screen visibility	0	2	32	65	48
Screen visibility in the presence of internal reflections	0	14	42	61	36
Location of MFDs for visibility	3	9	28	74	42
Location of MFDs for reach	2	7	24	74	49

40) Please rate the acceptability of the information content provided by the MFDs in your aircraft:

	Poor			Excellent	
Overall amount of information available.....	1	2	3	4	5
Organization of information across pages (hierarchy)	1	2	3	4	5
Ease of obtaining needed information.....	1	2	3	4	5
Layout of information on the screen.....	1	2	3	4	5
Customizability of information presentation.....	1	2	3	4	5

	1	2	3	4	5
Overall amount of information available	2	3	29	65	58
Organization of information across pages (hierarchy)	5	14	37	77	24
Ease of obtaining needed information	7	15	56	65	15
Layout of information on the screen	3	3	42	37	23
Customizability of information presentation	10	14	57	57	19

41) Please indicate how frequently the following events occur:

	Never		Sometimes		Always
Without looking at the MFD you know what page you are currently on.	1	2	3	4	5
When you know what information you want, you <i>immediately</i> know which page you need.	1	2	3	4	5
When you know which page you need, you					

immediately know how to get to that page (e.g.,
pushing the correct sequence of buttons). 1 2 3 4 5

When the MFD displays the page you need, you
immediately know where the desired
information is located on the screen.....1 2 3 4 5

	1	2	3	4	5
Without looking at the MFD you know what page you are currently on	11	30	48	55	14
When you know what information you want, you <i>immediately</i> know which page you need	2	34	66	47	8
When you know which page you need, you <i>immediately</i> know how to get to that page (e.g., pushing the correct sequence of buttons)	2	30	61	54	10
When the MFD displays the page you need, you <i>immediately</i> know where the desired information is located on the screen	2	28	40	70	16

42) Please suggest any changes to the MFD that might improve the visual displays/instruments.
Write any comments on the lines below.

All comments are provided in Appendix B.

If you have not flown the OH-58A/C or AH-64A before transitioning to the OH-58D or AH-64D, you
have finished the questionnaire. **Thank you for your time.**

If you have flown an OH-58A/C <u>or</u> an AH-64A, please answer the questions on the next page.

Transition from traditional to glass cockpit model
(ONLY FOR D-MODEL PILOTS WHO HAVE TRANSITIONED, OR ARE IN THE PROCESS OF
TRANSITIONING, FROM A/C-MODEL AIRCRAFT!)

43) With respect to the visual displays/instruments, characterize your transition from the
traditional model to the glass cockpit model.

1 2 3 4 5

Very difficult

About right

Very easy

	1	2	3	4	5
AH-64A	5	38	68	21	5

44) With respect to the visual displays/instruments design, which model of aircraft

	Definitely traditional		About the same		Definitely glass
is safer?	1	2	3	4	5
would you prefer to fly?	1	2	3	4	5
has lower workload levels?	1	2	3	4	5
is easier to learn?	1	2	3	4	5
promotes better crew coordination?	1	2	3	4	5
promotes better awareness of the aircraft in the flight environment?	1	2	3	4	5
promotes better awareness of the aircraft's status?	1	2	3	4	5
better allows you to perform your missions?	1	2	3	4	5

	1	2	3	4	5
is safer	3	18	53	34	26
would you prefer to fly	3	4	24	34	69
has lower workload levels	15	26	38	34	22
is easier to learn	36	37	37	12	12
promotes better crew coordination	3	20	32	40	32
promotes better awareness of the aircraft in the flight environment	3	6	18	48	58
promotes better awareness of the aircraft's status	1	9	14	42	68
better allows you to perform your missions	0	3	22	42	65

45) Please suggest any changes to the visual displays/instruments or the training that might improve the transition process for this aircraft. Write any comments on the lines below.

All comments are provided in Appendix B.

Appendix B.

Written responses to open ended questions.

Question 15. Please suggest any changes to the visual displays/instruments that might improve workload levels for this aircraft.

AH-64A

- Instruments are too low and there is too much moving around to conduct tasks.
- Buy a TST!! (make it a medical recommendation!)
- No changes. I feel the system is fine and much of an improvement over the AH-64A. However, at my experience level it is a struggle until I become more familiar with functions & locations.
- Composite or selectable display between FLIR and NVG image.
- Move all left/right console controls sorwerl to no surffer aff then the area of the power levers.
- Remove the ORT from front seat.
- Remove ORT.
- Provide a better visual view i.e., placement of radio preset channel and frequency display.
- Larger display.
- Design all gauges to read 1-100% in the green; above 100% yellow/red Vs. multiple numbers that really doesn't matter in the overall scheme- is it within limit, cautionary and or critical that is important to the limit.
- Commercial aircraft have been using glass cockpit for years. We definitely need to get into that division.
- AH-64A has dissimilar cockpit design. The ORT in the front seat is a major design flaw. The pilot in the back seat should be able to confirm front seat input.
- Remove the ORT and replace it with CRT. Keep the front and back seat instrumentation as similar as possible. Symbolic and actual indications should match i.e., TQ.
- Most instruments are blocked by the ORT, must lean sideways to see.
- This has been addressed in AH-64D.
- Centralizes displays with all encompassing information.
- AH-64A should have the same MFDs as the long bow.
- Clearly questions of displays in aircraft and task. OH-58D uses 1 MFD per pilot and other AH-64D 2 MPDs. RAH-66 initial MEP has 4. Issue is how deep and tiered menu structure is.
- Hard buttons entry points for more features. Excessive use of term utility page.
- We should have multifunctional displays with labelling in direct view. The front seat instrument cluster should be centered and complete with having to flip switches to monitor different things.
- AH-64D setup.
- Consolidate instruments in areas by type i.e., flight, engine, weapon etc.
- All tactical radios in the front seat(i.e., FM radios) remove ORT in front seat.

- The front seater needs a turn and slip indicator like the back seater has.
- Consolidate the FCC onto an MFD like the EGI has. Remove or drastically improve or shrink the ORT.
- Reposition the AN/ASN-137 DNS to more accessible viewable location. Make the ORT smaller, heads out display larger. Trim back in front seat, radar altimeter, HSI in the front seat.
- Certain switches require me to look at and locate the switch. Transponder is in a awkward place as is the tail wheel unlock/lock switch.
- Disregard MFD's.
- I fly the AH-64A we have no visual displays except HDU.
- Provide all engine instrumentation in the front seat to allow quicker determination of engine and drive train failures. Organize instruments so they are not obstructed by the ORT which is prone to causing leans under instrument.
- Due to TADS/ORT placement, interacting with gauges in FS in AH-64A sucks, the HDU is the only useful way of getting info.
- How about a true HDU.
- The ORT makes workload extremely hard. Removing the ORT and designing a new hands on terminal for gunnery purposes will be better used.
- Remove ORT.
- Better RMI HSI for the CP6. Air speed indicator located out of the way of ORT. Fire Pull handle relocated to the top of the dash for easier recognition. Make the light brightness on the FCP brighter than the instruments.
- Have flown both EGI and non EGI aircraft. EGI is a much better upgrade that the Army should invest in Army wide including CMS.
- Update the FLIR to current technology.
- Gen II FLIR.
- No change to display/ instruments. We need the upgrade to the FLIR/TADS.
- Adding MFD that included moving map display. Adding MFD that could be used for IMC/IFR flight to include appropriate navigation equipment E.G, IFR certified GPS, VOR, DME TACAN, ILS.
- How about an updated FLIR.
- More flight instruments/weapons switches from behind ORT. More flight instruments in front - SDD bad design EGI takes too many steps to get to important data- range info TGT report.
- Color more friendly to night flying.
- A full visor display instead of HDU.
- Remove ORT HDD replace with MPD.
- Reduce size of symbology display by 25% in HDU so all information is displayed all the time.
- AH-64 move instruments so that hand grips are not in the way. Make the front and back seat as similar as possible.
- Like to see the CDU mounted differently in the front seat. Needs to be tilted forward or higher instead of flat down on the right console.
- Why am I flying with one eye? Why do I have mediocre FLIR?

- When not using HDU in front seat torque and some instruments and gauges are slightly blocked.
- Instrument placement due to ORT only removal would provide improvement.
- The only thing I would like to see is, some sort of display in the back seat showing the grid I am at. All RAV info is in the front seat. A moving map would be nice.
- The front seat set up for the AH-64A is very poor. The instrumentation is not readily available. I suggest the removal of the ORT and simulate the BS as much as possible.
- Move to AH-64D design in all aircraft.
- Look at as many fixed wing instrument display, especially those used for IFR operations regularly and adapt those to our proposed dashboard.
- Ensure simplistic navigation of information pages.
- Initially when learning to fly the visual displays are mentally overwhelming in a AH-64A.
- Move caution/warning panel up for easier diagnosis of master caution and related caution/warning panel.
- Better designed pilot/sight interface for adjustment, function.
- Instruments needed for unaided flight are tough to see. Due to the fact that they are behind the ORT.
- The torque and airspeed indications are difficult to use because they are hidden behind right hand grip of ORT. There is no turn slip indicator in the Fs (unless pull up pilot symbology which isn't always preferred. Solution redesign layout of instrum[ents].
- They have already been improved on the D model.

AH-64D

- Moving map, more fixed action buttons.
- Place MPDs higher on dash so that pilot/CPG spend less time "heads down."
- With only two displays, I tend to feel restricted as to what information is immediately available while in flight, as compared to what is available.
- Change the default location for the flight page to the right UPD because that is the location of the standby instruments.
- Performance planning display- very busy needs to be reorganized.
- Remove the ORT, it is much easier to manage systems with 2 side by side panels as opposed to 2 panels separated by the ORT.
- Provide tail for ADF pointer on flight page.
- Voltage indications in aircraft. Hydraulic indication on up front display standby instrument in the front seat.
- Third MPD in front seat-Remove ORT.
- Great improvement in the glass cockpit of the AH-64.
- Possible put more MPD controls on the collective/cyclic.
- Get rid of ORT in AH64D.
- I have 1.9 hours in the airframe. probably also has to do with the little experience I have use trackball cursor control rather than present pressure cursor controller.

- Add one more MPD that generally (only) monitors system instruments (you don't have to switch pages that often then).
- They are pretty well designed. All buttons including ORT need backlights.
- More use of cursor (i.e., being able to use cursor to draw actual layout of power lines for example). Make pages more open ended allowing for more modification of routes, target assignment.
- Not enough experience to comment.
- Leave as it.
- At this point things are more confusing and frustrating due to having a set way of doing things and now trying something new. I am sure things will get easier as I spend more time in the a/c.
- Need a third MPD in front seat of AH-64D. The ORT currently in use is too small of a screen to be easily viewed when on a mission. Also, ORT handles are entirely too "busy." Some of the function buttons should be moved to the third screen bezel.
- Bigger MPDs, more FABs (All top-level MPD pages should have FABs outside the MPD).
- Please provide standby airspeed attitude and altitude analog instruments in both crew stations.
- A true HSI format.
- Move ORT and add third MPD.
- MPDs are great minor corrections in varied terminology are needed i.e., shot at BDA options logic sequencing can be improved for menu items. Overall situations is adequate.
- Emergency procedures should not have to require finding certain pages to turn on or off systems. A hard switch should be available for speedy on/off during emergency situations.
- Standby instruments in both CPG and pilot station.
- I think it would be better to survey pilots that have more time in this A/C. This a/c frustrates me now because I'm just learning it. Once I'm more familiar with it my opinion of it will probably change.
- During generator failure (dual) or complete loss of a/c power, there are no indication remaining for Np, Nr, Tq. The triple TAC should be reinstalled as part of the emergency flight instrument package.
- Develop 1 simple menu page that is arranged like a table of contents/INDEX. Access to a page # through the keyboard Unit.
- The basis for my survey is from a student's perspective. With time it will make our jobs easier.
- Currently unable to adequately assess cockpit design of the AH-64D. On first indication workload is great but as scan patterns are developed, workload rapidly decreases.
- If they could add the MSL ALT while the transition mode it would be nice.
- Continue to refine ergonomics i.e., move FLT page to right MPO and keep end page on left MPD during any engine/power train emergencies.
- AH64D cockpit is extremely user friendly. Reduces scanning and provides greater attention to be outside A/C.
- A lot of info for two screens.
- Only have 5 hrs in A/C. They need to develop a TSTT for the Longbow; ensuring LCTs are in all posts is very important for hands on practice.

- Customizable screens.
- Most of my high ratings are due to my inexperience in the aircraft and with the glass cockpit. I feel once the initial shock is over it will be a useful tool.
- Get rid of ORT and put in an MPD.
- Put analog FLT instruments in both cockpits. Maintain systems on MPDs.
- Removal of the AH-64D ORT would help front seat workload.
- A line diagram on the weapons page linking "swarm" element would aid in reducing time regd to fire weapon system at designated TGT.
- Not enough time in glass cockpit to make determination.
- If at all possible reduce the level of pages. Make a pure utility main page and would love to have a touch pad instead of a thumb force controller.
- Moving map display. Upgrade TADS/PVVS FLIR.
- Additional analog instruments.
- Put a third MPD in the pilot station.
- Better trainers to maximize hands on.
- Too many menu option per page especially, the top level pages.
- New FLIR, binocular sights, NVG usage should all be considered.
- Not enough time in AQC (supplemental) to be an effective crewmember in first unit after graduation.
- Glass cockpit is great but everything is on only 2 MPDs. So when you have to enable, disable or change something you are taking away an MPD. Add enable switches, eg. TADS, WPNs, XPNOR.
- The glass cockpit needs to move closer towards the accepted GUI design principles used in the commercial sector i.e., Mac/ Windows.
- Not enough experience in AH-64D to suggest.
- Eventually , I will be proficient in using the system. Right now it is frustrating because everything is new
- FLIR provides many false targets, so improve the FLIR accuracy. TADS/PNVs needs upgrading. Map holding patterns on the visual display.
- Digital cockpit makes trend detection more difficult than analog. Need less on instruments moving together. I would not mind digital instruments designed like analog ones. For example the HSI compass is difficult to use heading tape in the heads up v.
- Need TSTT trainer. MPDs have not eliminated the need for this.
- It's a criminal negligence that the navigation avionics suite on the AH-64A and now, the AH-64D loves us. The AH-64D does not include sufficient equipment to navigate the aircraft within the national air space structure under IFR.
- Too much info capability of equipment should not be confused with useability. Someone needs to remain focused on flying outside and the enemy.
- Remove ORT to 3rd MPD.
- Include amp in background.

Question 19. Please suggest any changes to the visual displays/instruments that might improve safety in your aircraft.

AH-64A

- Let a pilot re-design the cockpit.
- Symbology too spread apart for AH-64A closer symbology makes cross check easier. This problem results in pilot loosing some symbology. Upper left Vs. lower right.
- Move caution/warning display up to a point where the pilot's knee does not block direct view.
- Full view of symbology and FLIR picture.
- Remove the ORT from front seat.
- Reduce the size of the gunners FCP so that engine instruments can be displayed without the use of a selectable display panel.
- Provide a better visual view i.e., placement of radio preset channel and frequency display.
- Design all gauges to read 1-100% in the green; above 100% yellow/red Vs. multiple numbers that really doesn't matter in the overall scheme- is it within limit, cautionary and or critical that is important to the limit. Get rid of the ORT no need for it.
- Move tow and glass cockpit that is exactly the same in both seats.
- Need to be like cockpits with the ability to confirm opposite seat inputs.
- Remove the ORT and replace it with CRT. Keep the front and back seat instrumentation as similar as possible. Symbolic and actual indications should match i.e., TQ. Improve the caution warning panel to be the same as the back seat.
- Never combine digital analog and marconi. Standardize radio control heads tandem seating increases risk.
- A visual display while maintaining outside situational awareness.
- Quality of FLIR video.
- Visual display information is highly related to pilot workload. Flying the aircraft and integrated flight management systems. Example RAH-66 MEP development is predicted on VELSTAB.
- Hard buttons entry points for more features. Excessive use of term utility page.
- We should have multifunctional displays with labelling in direct view. The front seat instrument cluster should be centered and complete with having to flip switches to monitor different things. The front and back seat should be identical.
- Same as for workload, consolidation by type with given area.
- Remove ORT and replace with glass cockpit.
- Remove the ORT. It has killed too many front seaters.
- The missile system is too complicated, too many switches, the ORT head's out display is too small and Gen 1 FLIR is poor and dangerous.

- Reduce ORT size or remove it all together.
- Reposition the AN/ASN-137 DNS to more accessible viewable location. Make the ORT smaller, heads out display larger. Trim back in front seat, radar altimeter, HSI in the front seat. Blue green lighting in cockpit (standard in Army fleet).
- It seems that with the AH-64D, many of the problems associated with the problem indicated earlier have been corrected.
- Disregard MFD's.
- Provide a CDU read out for the back seat pilot to check maps and position and allow other crew members to remain focused outside of aircraft.
- Pull handle relocation.
- Perhaps more gauges away from behind the ORT causing you to physically move around the TADS ORT to see some of them.
- A better VDU in the backseat and a bigger heads out display in the FS
- GEN II FLIR.
- New improved FLIR/TADS.
- Adding MFD that included moving map display. Adding MFD that could be used for IMC/IFR flight to include appropriate navigation equipment E.G, IFR certified GPS, VOR, DME TACAN, ILS. Also CPG station design could contribute to spatial disorientation du.
- Updated FLIR and HDU.
- More flight instruments from behind ORT. Give CPG TGT, OIL PSI, fuel, NG instruments. Give CPG full caution/warning panel.
- A switch on cyclic or collective which allows to switched from PLT/CPG pictures.
- Glass cockpit get rid of ORT and replace with larger VDV screen up against instrument panel.
- Low altitude audio warning reduced size symbology in HDU.
- Like to see the CDU mounted differently in the front seat. Needs to be tilted forward or higher instead of flat down on the right console. Have a BAT and contrast adjustment knob on collective head instead of VDU to limit hands off. Also to tossle be.
- Why am I flying with one eye? Why do I have mediocre FLIR?
- Change the lighting in AH-64A to blue green. Get rid of ORT and make hand grips smaller.
- Same display in front and back seat instruments in exactly the same place.
- GEN II FLIR in an older model AH-64's.
- A TADS with generation 2 FLIR and a faster slew rate. A PNVS with generation 2 FLIR
- Better visual acuity, wider FOV.
- Front seat CPG station right ORT handle grip blocks engine instruments.
- Get rid of the ORT in the front seat. A single visual display console could do more to improve mission accomplishment, situation awareness, reduce pilot overload and increase efficiency. Not to mention it seem that every front seater hits this thing wi.

AH-64D

- Improve back up instruments. Incorporate more FAA approved nav aids.
- The only negative is people focus on MPDs. This is human factors not MPD design.

- Moving map display with TSD. FAA approved GPS database for IFR NAV and GPS approaches.
- Place standby instruments higher on dash as well as make them larger.
- Possibly one additional MPD to increase immediately available info. More importantly, behavior modification training is paramount to prevent both pilots from focusing within the cockpit simultaneously, especially during gunnery/tactical trg.
- Second generation FLIR (possibly not your field).
- It would be nice to have engine page instruments displayed at all time.
- Standby instrument in the front seat
- GEN 2 FLIR would greatly improve safety in the AH-64D/A
- Removal of AH-64D CPG station "ORT" could improve safety. ORT Functions could be integrated into 3rd MPD.
- More auto-paging for emergencies.
- See #15 (I have 1.9 hours in the airframe).
- Get rid of ORT.
- Upgrade to Gen 2 FLIR.
- (Refer to previous recommendation.) Third screen and bezel button would reduce greatly the chance of wrong switches being pressed in the dark and reduce attention inside the aircraft of both pilots during missions.
- The installation of the emergency procedure checklist would increase the pilot (not on the controls) ability to backup the pilot. Flying the Aircraft, much quicker keeping him more, situationally aware.
- GPS database that is FAA approved for IFR flight i.e., GPS approaches.
- Moving map display with color and terrain relief.
- Third MPD for back seat.
- Eliminate the ORT in AH-64D CPG station and replace with MPD. This would allow CPG to better divide focus inside and outside.
- Improve sight systems i.e., PNVIS-FLIR, instruments package for IIMC.
- ORT is in the way causing you to move around in the front seat to see all of your info.
- Improved HDU.
- Unfortunately the MPDs cause fixation inside the aircraft.
- Glass cockpit design with VABs and Fabs causes a greater need to be focused inside the aircraft.
- The AH-64D is well designed except as #15 above. The pages should have a schematic or layout to learn for ease of use prior to AQC training (that is web address format).
- In my limited experience, the ECS temp control should not be in the MPD. The reostat switch we had in the AH-64A was much more convenient.
- Replace ORT with a 3rd MPD. FLIR II System for better TGT I.D. (friend/foe).
- HDU by the BRY, sometimes day flying is difficult with HDU. Ability to go directly to page opposite crewmember is viewing.
- Unless you can find an MPD format to eliminate aircrew mistakes there is not much else to do.
- Remove ORT it is too bulky and blocks the view and accessibility to the MPDs. That is I can't reach the right MPD with my left hand while flying in the front.

- Maybe better sensors or sights.
- Voice activation to bring up pages quicker and not let go of the controls.
- Allow radar to look up for precipitation.
- More nomenclature.
- I've still got more than I can handle right now.
- Change PNVs Tads sensor/sight systems to FLIR GEN Z.
- MSL ALT could be added to transition symbology so you can reference ground track and ALT's at the same time or add velocity vector to cruise symbology.
- Not enough time in glass cockpit to make a determination.
- Remove the ORT to enable unrestricted viewing of both MPDs.
- IS at all possible reduce the level of pages. Make a pure utility main page and would love to have a touch pad instead of a thumb force controller.
- Moving map display. Upgrade TADS/PVVS FLIR.
- Put a third MPD in pilot station.
- More fixed action buttons.
- Bigger, make them larger if possible.
- Sort through page layouts, minimize stuck sub pages.
- MPD's and dashboard in backseat) are about 1-2" too low. As a longer legged pilot, I cannot use park brake in back seat and can't see all of MPDs in front seat.
- There is a lot more stuff added to the longbow than the "A" and only 2 MPDs.
- Industry standard GUI with a better access device to drive cursor/select. Displays need millions of colors not just 16 and have actual map (cadra/DTED/CIB) information below route graphics.
- Use analog instruments - a circled compass rose is generally missed. I used to just see 45 and 90 degree tick marks on the HSI. Now with only a hdg tape I have to do the math in my head for traffic pattern work.
- ORT needs to go now. FLIR needs upgrading now. Money is there but it is still not in my A/C. War is here now lets fix it. Also, goggle qual in AH-64D here.
- MPD would be better if they were higher about 3-4 inches.

Question 25. Please suggest any changes to the visual displays/instruments that might improve crew coordination for this aircraft.

AH-64A

- Need to have indications of what the other crew member is doing (i.e., KU illumination, etc).
- Front seat needs drift and climb rate info during target engagement to predict impact point of weapons.
- Gunner symbology needs drift info.
- No climb or drift info provided. Front seat during weapons engagements.
- Have frequency display in both seats so either crew member can see what is up on any radio.
- Create an interface between the CDU and the VDU.

- Mission changes becomes labor intensive for CPG station while pilot 'waits' for data input by CPG. No fix for this.
- Move tow and glass cockpit that is exactly the same in both seats.
- Need to be like cockpits with the ability to confirm opposite seat inputs.
- Audio to go with the light aka AH-64D. APR 39 that actually is right. Better color coding of lights to indicate severity of problem.
- Each cockpit different-Bad idea cockpit essentially same in Longbow.
- Unless both crew members are proficient in accessing all the information displayed, verbal crew coordination/ conformation will still be a requirement.
- Good habits from the start.
- The ability of opposite crew member to override on "illegible" function "illegible" needs to be numerous.
- In OH-58D easy to monitor /cross check other crewmember not so in the tandem seat. Need different design approach given seating arrangement.
- Hard buttons entry points for more features. Excessive use of term utility page.
- The instrument promotes crew coordination as the instruments in the two cockpits are different. Instruments should be the same for both crew stations.
- Reposition the AN/ASN-137 DNS to more accessible viewable location. Make the ORT smaller, heads out display larger. Trim back in front seat, radar altimeter, HSI in the front seat. Make the mail slot larger so that it can be used.
- Many things in the A model Apache are cockpit specific and are not duplicated in each cockpit. This prevents sharing workload to a point.
- Disregard MFD's.
- Make pilots VDU switches closer to the pilots hand like on cyclic or collective.
- Have an alphanumeric representation of whether the FLIR is in black or white hot. Example A "B" or a "W" in the center of the los.
- RMI HSI same as backseat airspeed indicator relocated.
- New, improved FLIR/TADS.
- Lack of crew station commonality instrumentation contributes to the necessity of excessive verbal communication in a tandem seat aircraft.
- A 137 control head in the backseat and better adjustable VDU.
- More flight instruments from behind ORT. Give CPG TGT, OIL PSI, fuel, NG instruments. Give CPG full caution/warning panel. Allow CPG to be a better informed crew member.
- Crew coordination isn't based on instruments it requires constant assertion by both pilots in a dual cockpit aircraft.
- Full instrumentation in front seat.
- Like to see the CDU mounted differently in the front seat. Needs to be tilted forward or higher instead of flat down on the right console. Have a BAT and contrast adjustment knob on collective head instead of VDU to limit hands off. Also to tossle be.
- Buy a better FLIR and maybe a new HDU for ease of viewing.
- Put a trimball in the front seat that is not electronic (one not on flight symbology like we have).
- The front seat set up for the AH-64A is very poor. The instrumentation is not readily available. I suggest the removal of the ORT and simulate the BS as much as possible.

- Put same caution/warning panel in front and back seat of AH-64A.
- Voice warning to promote crew situational awareness in case both individuals get too engrossed in the visual displays.
- Symbology helps; however better visual acuity and wider field of view.
- Fuel quantity total in front seat would be helpful.
- If a single visual display console was put in to replace the ORT a moving map could be available to the front seater thereby exponentially increasing situational awareness during ingress abf/ea and egress as well as improving greatly crew coordination.

AH-64D

- A scratch pad for both crew to input data. Improvement to free text function and IDM messaging to ease use.
- No ability to monitor the opposite crew member's symbology/actions.
- Small window stating what MPDs pages are up in the other cockpit.
- Crew coordination is made more difficult because the front seat pilot must devote much time to setting up the battlefield properly, the pilot in the back seat does not see changes as they are happening.
- At the different station crew members can make changes and if the other pilot is not looking at that page he/she will not know it has been changed.
- Would benefit crew-coordination if crewmember could view other crewmembers MPD, see exactly what the other is viewing.
- More independent crew station separate MPD functions to force crew coordination.
- A method is required by which one crew member could see another crew members display.
- See #15 (I have 1.9 hours in the airframe).
- The design do not promote crew coordination. The crew members must initiate crew coordination.
- Have function in pilot's station that allows him to see what CPG is doing on HSI MPD's.
- Change indication of the page displayed and functions selected by one crew member when the same page is viewed by opposite crewmember. This would help avoid continually selecting the same function by both crew members at the same time.
- Visual displays not only promote good crew coordination they necessitate it.
- Add another system page that indicates which crew member has control of certain systems (i.e., color code or identify who has PNVS/TADS, who has certain weapon selected). Add another icon on UFD to indicate when crewmember is transmitting on a given radio.
- Replace the ORT on the Longbow with another MPD.
- Crew coordination is a much bigger issue with the AH-64D due [to] the MPDs and the ability for each crewmember to make changes and decisions separately from other crewmembers.
- Develop a link function for one crew member to display another crew member's exact MPD page on their's.
- Crew coordination training is needed for glass cockpit aviators, not redesign.
- Crew coordination is on the crew. The MPDs only trigger or remind them to coordinate.
- Cockpit unique controls that cannot be manipulated by the other crew member.

- My low experience levels does not give me much to draw good conclusions.
- Not enough experience to give a suggestion.
- Limit the button "step-ons" two pilots up same screen, press button, and counter each other.
- There seems to be too much duplication between what each crewmember can do. That is good in many ways but it requires strong crew coordination to make it work.
- None at this time.
- Fixed action button to (illegible) page or a different access via a z axis aspect as we have with flight page.
- You must have crew coordinator because of all the common button.
- Indication in each crewstation, on each page, as to what pages the opposite crewmember is on.
- The MPD's do not promote good crew coordination but they require better coordination in order to be safe.
- In cockpit camera maybe?
- Being able to see what the other guy is doing (what pages he is looking at). Ability to pull up the other guy's pages.
- Video select position for monitoring opposite crewmember screen selection.
- Need to see what the other person is looking at, at any time.
- The challenges of crew coordination posed by having A/C common switch settings are significant, but off set by the ability of either CM having access to the switches.
- MPD's cannot be monitored because so much is station specific but impacts on entire flight, if is great anyone can change it but by sharing all duties it increases crew coordination duties/verification in order to ensure info is not lost or missed.
- Not enough time in glass cockpit to make a determination.
- Having a third MPD in both cockpits not just the proposed to replace the ORT.
- Add a capability for each crew station to know what the other crew member is displaying.
- Ability to view other crew members pages.
- With inexperienced person in cockpit workload increases ten-fold for other crewmember. Need more training devices (i.e., TSTT) that simulate full cockpit without wasting blade hours.
- It would be beneficial in some cases to have some indication of what is cockpit related as opposed to A/C-related when making input on MPD's. But crew coordination still has much less to do with the hardware than with the training of the crew.
- Crew coordination is a must in the A/C.
- Analog combined with heads up would be great. Maybe put a small compass rose in the heads up with a wind arrow on it.
- Remove ORT, replace it with a small screen with fixed flight symbology period.

Question 32. Please suggest any changes to the visual displays/instruments that might improve situational awareness for this aircraft.

AH-64A

- The AH-64A is a bad design and should be completely re-designed.

- Buy a TSTT! (make it a medical recommendation, as a way to reduce pilot stress).
- Pilot has no Alpha numeric display in -51 software.
- LMC on would be nice to have some sort of indication.
- Design all gauges to read 1-100% in the green; above 100% yellow/red Vs. multiple numbers that really doesn't matter in the overall scheme- is it within limit, cautionary and or critical that is important to the limit.
- Move tow and glass cockpit that is exactly the same in both seats.
- The need to see all instruments without having to bend down or look over. Quick reference is the key.
- Larger more distinctive lights maybe. Easier to read.
- CPA and CW should be same as PI. All displays should be same as PI.
- HDU is terrible-Need to see info with both eyes.
- Optimistic scaling does not appear to work as advertised in the -10. Most aircraft on the flightline, applying optimistic scaling are flying at 98-99% NP/NR.
- Improve TADS and PNVIS in the AH-64A/D.
- Connect the Enns for displayed long. On the VSD so if needs completely.
- Again question of menu depth and cluster on display. 2 MPD Vs. 2MPD, 2 other displays.
- Hard buttons entry points for more features. Excessive use of term utility page.
- We should have multifunctional displays with labelling in direct view. The front seat instrument cluster should be centered and complete with having to flip switches to monitor different things. The front and back seat should be identical.
- Displays in front seat are not sufficient for flying as they are off at an angle and lent to spatial disorientation.
- Install the same HSI/RMI in the front seat that the back seat uses.
- Reposition the AN/ASN-137 DNS to more accessible viewable location. Make the ORT smaller, heads out display larger. Trim back in front seat, radar actimeter, HSI in the front seat. Blue green lighting in cockpit (standard in Army fleet). Trimball/sl.
- Once again I think most of the problems associated with the A model Apache has been corrected. I would like to see a moving map display to improve situational awareness.
- Disregard MFD's.
- Allow the pilot on the controls to access any information that is thought to be necessary.
- If I were able to access GPS Grid in our HAD by a switch on collective/cyclic would be handy.
- RMI HSI a new SDD.
- GEN II FLIR.
- New improved FLIR/TADS.
- The addition of a second EGI control head independent from the CPG's in the back seat would be a welcome addition. The PC who is responsible for the location of the aircraft visually sits in the back seat and must relay on the CPG for navigational info.
- More flight instruments from behind ORT. Give CPG TGT, OIL PSI, fuel, NG instruments. Give CPG full caution/warning panel. Allow CPG to be a better informed crew member.
- Placed higher possibly on windscreen.
- Make the important instruments easiest to see.
- Make torque easier to see in front seat when flying without the HDU. Bigger HOD/VDU.

- Selectable digital display requires action to monitor all systems.
- The front seat set up for the AH-64A is very poor. The instrumentation is not readily available. I suggest the removal of the ORT and simulate the BS as much as possible.
- Augment with voice warning systems.
- Generation 2 FLIR and faster slew rates.
- Adding a single visual display console with a selectable moving map and TQ and turn slip and HOD greatly improve operations in the front seat.

AH-64D

- Moving map (contour lines, vegetation, satellite imaging on TSD. Increase response time of ENG/ASE autopaging display. UFD display of exceedance info.
- Map underlay! Now you just follow lines it draws you inside a little too much there is too much to see on the inside.
- Possibly include other pages on HMDs.
- More autopaging and more selections per page MPD page structure goes too deep.
- Upgrade to Gen 2 FLIR.
- Too many menus/screen. Actions that used to take only the push of a button now take longer since we are forced to navigate through multiple "pages."
- A moving map should be incorporated as an underlay on the TSD page.
- Moving map display.
- For performance planning make the calculations more accurate and reliable and if possible dynamic throughout flight period.
- Standby instruments for the CPG station.
- Makes you focus inside more than outside.
- Again the MPDs bring you inside. An excellent tool though for A/C performance situational awareness.
- Moving map display underlayed on TSD page.
- Seems both crew members can get sucked into the MPDs and nobody looking outside. "SA" training can counter this.
- Confidence will come with time if the displays prove reliable.
- Falcon View 3.1.1 would be a great addition to the situational awareness through map database management 1:500000, 1:250000, 1:50:000; DTED, IM CIB. (Route analysis, terrain analysis, ABF/BP analysis during MSN chngs).
- Integrate more combined arms/joint aspects so we can tack to or get info from the right square at the right time.
- Display an MSL attitude in transitor mode of the HDU. Just a suggestion that bothers many pilots even though it isn't panel mounted.
- As stated earlier glass cockpit on AH-64D is a huge advantage and allows crewmembers to focus more outside A/C.
- MPDs promote more time inside the cockpit. In my 1-6 hr flight yesterday, I was probably outside for 0.2.

- Moving map underlay with elevation data, real-time emitter download from an external source with LDS information displayed.
- I answered neutral on several of the above questions, once again because of my relative short time in the aircraft and all of it is pretty overwhelming at this point.
- Put Eps in aircraft.
- The only place on HSI is allowed is on an already cluttered NAV/Attack page, either an analog HSI or glass HSI should be added to allow P and P to determine HSI position relative to sit without thinking with heading type.
- Not enough time in glass cockpit to make a determination.
- Put a third MPD in pilot station.
- NR and NP reference displays are too slow from the time it takes to set from the engines and NR sensor to the displays.
- I am still tied to a large and cumbersome paper map, requiring that I now divide my attention yet once more.
- Improve visual display from FLIR. FLR - the number of false targets.
- Both seats need a fixed digital or analog B/V, flight symbology on DASM.

Question 36. Please suggest any changes to the visual displays/instruments or AQC training that might improve learning to use the visual displays/instruments in your aircraft.

AH-64A

- Buy a TSTT.
- Computer simulations at home on personal PC.
- Periodic practical exercises with the use of D.E.K. 137 CDU function and switches. Self paced, multiple short training periods throughout.
- Design all gauges to read 1-100% in the green; above 100% yellow/red Vs. multiple numbers that really doesn't matter in the overall scheme- is it within limit, cautionary and or critical that is important to the limit.
- Move tow and glass cockpit that is exactly the same in both seats.
- Emergency recognition is just as important as memorizing underlined stop.
- The AH-64D has a slick program for working the MFD's.
- You must teach EP recognition not just EP steps.
- Use of dynamic computer displays in the class room. We are using power point presentation in the classroom showing how instruments look during malfunction however, the slides are not animated and have very limited utility. For example, how can we teach.
- Add more time to POI BAG training in the aircraft.
- Good positive habits
- Fix computer program, emen procedure try in simulator.
- OH-58D AQC much more interactive with training similarity than AH-64D. Must have HMDS on simulation while instrument teach.
- Hard buttons entry points for more features. Excessive use of term utility page.
- More flight time during and after AQC.

- Improve TSTT so it is free to do more things such as those as the CMS.
- Significantly more flight time focusing on tactical employment and navigation.
- More night system and instruction flight time.
- 64A AQC must include -51/-55 software, 701C and BUCS training. The CMS simulator must also be upgraded to reflect current equipment in field units.
- Do not change what works.
- Build proficiency through flying. No displays can take the place of air sense. All aviators need a base to build from.
- More IFR training.
- Best thing that can be done in my opinion is update the CMS for all AH-64A i.e., CDU functions.
- New improved FLIR/TADS.
- More one on one (instructor/student) time with instructor visually observing student's correct manipulation of display /instrument controls settings and adjustments.
- More in depth emergency recognition training in concept /CMS.
- More time in aircraft.
- More flight time. Simple but hard to get.
- Teach the current software to front seaters and make sure AQC aircraft have updated software.
- Buy a better helmet and HDU for Apache pilots to go with the Long Bow.
- Computer simulation especially instrument training.
- More NVS training flight.
- Explain the use of the heads out display (HOD) a bit more AQC. Tactical use of the HOD wasn't covered much. Example : at what point should fs switch from NVS to TADs and should be used the HOD or HDU.

AH-64D

- Mock up.
- The design of a more accurate "emulator" that can be issued to each student. The current emulation software has many anomalies.
- More hands-on training with aircraft or LCT would benefit learning process.
- More MPD hierarchy training.
- Keep the PC training emulators current with A/C configuration and distribute to students.
- More time in the LCT before going to the flightline.
- Provide MPD mock-ups for practice. Alternatively, computers with MPD emulator should also suffice.
- The 64D has limited access to the training simulator, there is a lot of procedures that cannot be practiced with computer software emulators.
- More hours less time spent on non aviation duties to include warfighter, airborne ops, parades report of survey's etc.
- Actual MPD's in classroom environment that operate like the actual equipment.
- Have Boeing produce an emulator that actually works as it does in the helicopter.
- More time pushing buttons on emulator or simulator.

- Make a Longbow static cockpit so that students can go over the start ups and MPD pages on their own time.
- If AH-64D AQC students could have access to LCT on the weekends or have available "mockup" cockpit at the learning center.
- Come up with a standard computer disc that works on all computers and can do all the functions of the acft. There are at least 5 emulators floating around.
- LCT periods need to be increased to at least two hours in duration each. Also, more periods should be allocated so more time can be spent not just getting introduced to what things look like, but also so students have time to employ what they think they.
- Need cockpit mock-up to get used to symbology.
- We need a switchology trainer similar to the AH-64A TSTT to practice on.
- There must be more training aids. For example, it is impossible to have access to addition LCT time. Student need a partial simulator especially for the CPG station for gunnery operations.
- Run actual mission scenarios during class computer training to increase positive habit transfer.
- Have a trainer (push button type at the Ed center for students.
- More LCT time.
- Software programs issued to each aviator and LCT time, ACFT increased
- Need to have a mock up for blind cockpit procedures. Split LCT (SIM) periods so they are not back to back to allow discussion. Increase flight line flights to 2.0 instead of 1.4 to allow more interactions of tasks in the A/C.
- Distribute simulator like the Air Force and Navy do to help out.
- Scenarios built into the computer training programs for performing a variety of tasks.
- Emulator that is true to software version issued to every student. TSTT device similar to AH-64A TSTT.
- Must practice or use to maintain proficiency.
- More simulator time.
- Develop a TSTT for the AH-64D.
- Have an MPD mockup like the TSTT.
- A computer-based MPD emulator for personal use that is current to the aircraft without glitches.
- Updated computer trainer "LPT" for practice at home or on computer.
- Better, more accurate home computer emulators, or something in the way of a C-WEPT type device that students can use without having an IP there.
- It is a shame to see so much money spent on computers in the classroom. Instead of paperweights, we should use these aids and incorporate them into the curriculum.
- There is a strong need to have some type of training device that the students can get access to similar to the TST of the AH-64A model.
- A better emulator (computer based program) that allows full functional use.
- MPD emulator. Need a TSTT for Longbow.
- A well-developed interactive computer program that loads on any home computer with actual pages.
- I have difficulty using computer training programs. Prefer having an instructor.

- If they could have a mock-up at the learning center like the AH-64A mock-up, that would be nice.
- Practical exercises dealing with WPNS, DMJ, commo, and NAV w/ interactive emulator.
- Have better MPD simulator.
- Get a new up to date emulator that works on regular basis.
- Some kind of a TSTT would definitely help. The only thing available now is the LCT and that requires an IP.
- Better and more complete have computer based display simulators.
- Have an MPD computer program in the learning center. Create a Longbow TSTT. Have more LCT time, get rid of supplemental course.
- We need a switchology trainer TSTT. The emulators are nice but don't teach switch positions.
- Provide system similar to TSTT. Make available to students at all times.
- Provide an accurate emulator to pilots. Instructors should teach classes in LCT to solidify class courseware it should not be the first time try in the acft.
- Not enough time in glass cockpit to make determination.
- Need a TSTT similar to the AH-64A.
- There should be more training in simulator provided for supplemental AH-64D.
- Correlate academic instruction with a flight line instruction i.e., when we're learning weapons on the flight line, teach weapons in academics.
- Need a TSTT type device to practice all MPD ops which include grip and ORT buttons/switches.
- Set up a system similar to the AH-64A TSTT for the longbow. LCT is good training but is available as much as the aircraft not too often.
- We need a trainer like the TSTT for the A model. I don't care about the cost it's essential to training.
- Put out up to date and accurate lot number computer training programs.
- Allocate more flight time allowances for unit level proficiency.
- Let pilots be pilots. The number of additional duties today is outrageous.
- Need realistic training CDs for the use of the MPDs.
- We badly need an updated emulator that will work reliably on newer computers, and much greater access to the LCTs.
- The emulator software is referred to by both the classroom and flight line as invaluable and essential to mastering the AH-64D. It will not run on half of the computers that my class has (personal). Laptops (that work) should be issued to students with it.
- Change academics to teach what you need to know in order to operate the A/C. Who cares that the speed of light is 186000mi/sec.
- Develop a TEAC for AH-64D.
- TSTT!!!
- SUPP course needs expanding 8 weeks.
- Up to date computer training GD(s) to permit students to practice after class.
- The AH-64D needs a TST.
- LCT device similar to TSTT (full mock up of cockpit).
- More flight time.

Question 38. Please use the space below to mention any other opinions you have about the visual displays/instruments on this survey.

AH-64A

There were no responses to this question.

AH-64D

There were no responses to this question.

Question 42. Please suggest any changes to the MFD that might improve the visual displays/instruments.

AH-64A

AH-64A pilots were not asked this question.

AH-64D

There were no responses to this question.

Question 45. Please suggest any changes to the MFD that might improve the transition process for this aircraft.

AH-64A

AH-64A pilots were not asked this question.

AH-64D

- More MPD training on the hierarchy of how the pages flow. If you know how to get to a page quickly, the MPD tells you what to do there.
- See #36 More time in the LCT before going to the flightline.
- The AH-64D AQC should have a workable computer simulation that can be distributed on ACD to the students.
- A higher quality NVS would best promote safety. I am concerned about all my instrumentation being provided by MPDs.
- Give this questionnaire again at a later date to same individuals to see how opinions change as they progress after training.
- We need training programs/trainers to practice.
- More flight time in aircraft.

- Should have backup instruments in front seat. More training should be available, more flight hours.
- There will be accidents caused by MPDs. It is inevitable.
- More flight time.
- A training simulator that is up to date with the aircraft available during training and AQC
- More computer simulation, and LCT time.
- Classroom - More computer or MPD operation (switchology); LCT- More hours (procedures); A/C -More hours (tactics).
- Practical exercises with an interactive emulator.
- Although this is valuable information. I think you [would get] more intuitive responses if this was given to the pilots that have flown the glass cockpit for at least a year. I am sure if I was given this next year some of my opinions might be different.
- The low rating for safety is because, at this point, I am "inside" the cockpit more than ever to learn the system. I feel that we need more LCT time, more so than flight time, for more "button pushing" experience and a chance to better learn the pages.
- I'm currently in transition course, ask me this information in about one year after flying and teaching the aircraft and course.
- Promoting better Cc and making less intrusive are two different things, yes work can be divided up. But also means more are apt to be forgotten or missed.
- Not enough time in glass cockpit to make a determination.
- Allow more time for training and have a station for MPD manipulation.
- Repetition is the key to success. The more times you perform a given task, the easier it becomes.
- Looking forward to have moving map display for greater situational awareness in the near future.
- We are very new to the AH-64D, our interaction with it and the various systems is what is completely new to us. After flying and some experience in the cockpit. Push-in buttons and learning how to crew coordinate actions and employing the machine.
- TGT and triple TAC standby instruments.
- More flight time. LCT time and classroom time.
- Traditional cockpits are easier for awareness of the flight environment simply because there are less distractions.
- See #36 and add three exclamation marks.
- Let me take this survey one year from now. Answers will be different because of higher experience level.



DEPARTMENT OF THE ARMY
**U.S. Army Aeromedical
Research Laboratory**
Fort Rucker, Alabama 36362-0577